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THE PHYTOPLANKTON OF THE NORTH SEA AND ADJACENT WATERS IN MAY 1948

BY

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Preface.

During the International survey of the North Sea and adjacent waters in May 1948, arranged by the International Council for the Exploration of the Sea (the Sub-Committee for Combined Hydrographical-Biological Investigations), phytoplankton samples were collected at every other station in the hydrographic sections. The microscopical examination of the Danish and English material (sections R, S, T, U) has been carried out at the Plankton Laboratory, Copenhagen, by Jul. Grøntved, while the Scottish, Swedish and Norwegian material has been examined at the Biological Laboratory of the University of Oslo. K. Ringdal Gaarder examined the samples from sections A, B, C, D, E, most of F and G, L, M, N, P and Q, while cand. real. Ottar Nordli counted those from sections H, J, K and the rest of F and G.

A grant from the International Council for the Exploration of the Sea covered expenses for the Norwegian part of the microscopical work and "Rask-Ørsted Fondet" contributed to the Danish. Also "Fondet for Dansk-Norsk Samarbejd" and "Norsk Varekrigsforsikringsfond" paid some of the travelling expenses in connection with the work.

Hydrographical data for 1948 have kindly been placed at our disposal through Dr. Jens Eggvin.

Jean Holmes has assisted in computing plankton tables and making charts.

We wish to thank all who, in one way or another, have aided us in carrying out the investigation and preparation of the manuscript.

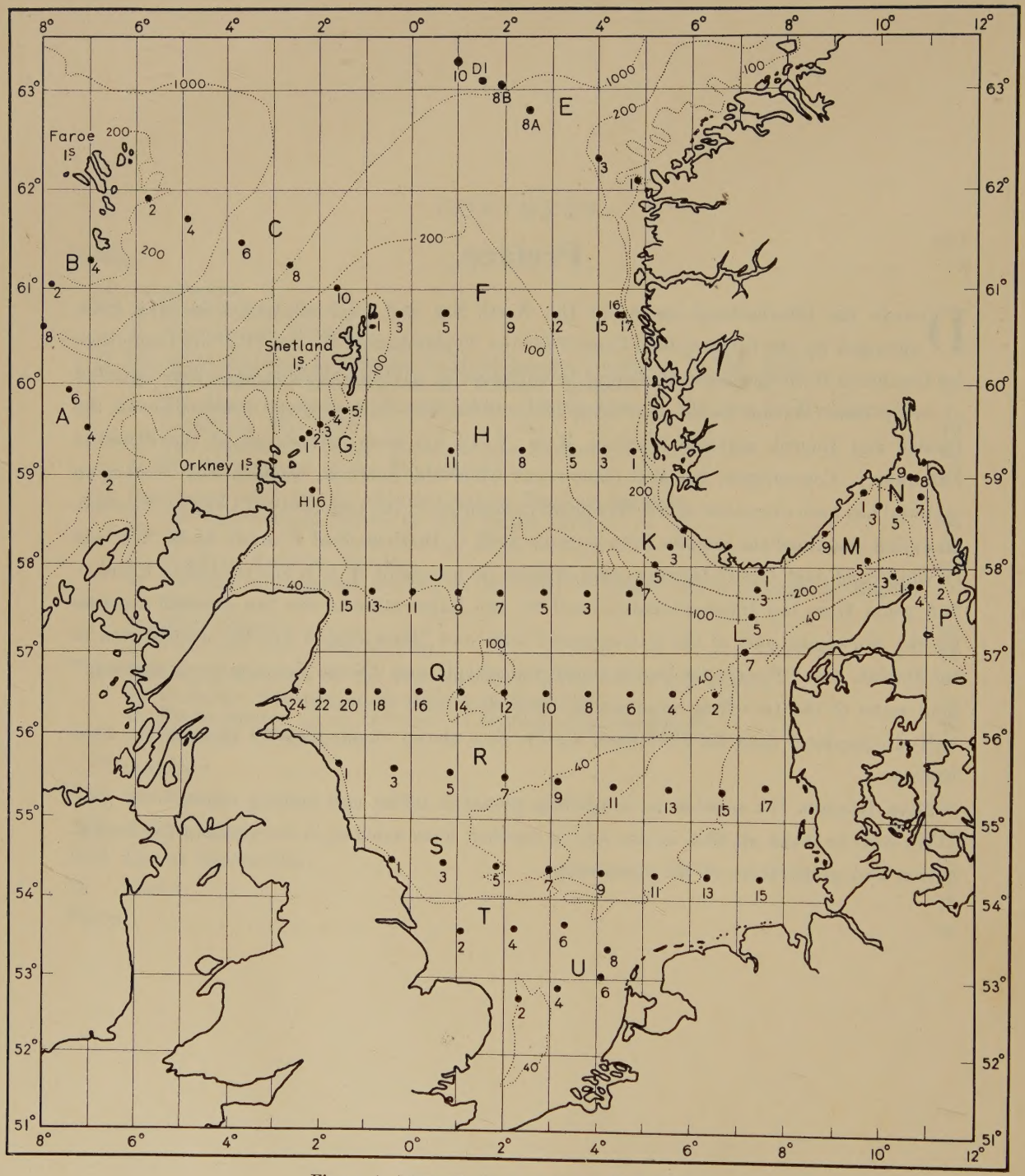

Figure 1. Phytoplankton stations, May 1948.

I. Introduction.

A. General Remarks.

In presenting the results of the phytoplankton investigations in the North Sea and adjacent waters, May, 1948, stress is being laid upon a comparison between the phytoplankton distribution and the hydrographical conditions. In order to facilitate the discussion of our data from this point of view, it will first of all be useful to make some comments on the ecological aspects of phytoplankton studies, especially on features which seem to be most promising when trying to understand the ecological background of the mosaic of plankton societies encountered.

a) Methods.

The following methods have been used for ecological phytoplankton studies within the region: the net method (CLEVE 1897, 1900 a, b, 1902 etc., APSTEIN 1905, SAVAGE and HARDY 1935, SAVAGE and WIMPENNY 1936), the centrifuge method (GRAN 1915, GOOR 1923, WULFF 1925), the plankton recorder (HARDY 1935, LUCAS 1940, 1941, 1942) and the sedimentation method (GRØNTVED 1952). These methods may be evaluated differently according to the purpose of the investigation. The net method has yielded interesting data relating to the distribution of microplankton. The plankton recorder gives qualitative information on patchiness and seasonal distribution of large species. For a study of the phytoplankton community as a whole these methods would, however, not seem to serve the purpose, since nanoplankton is not recorded and the plankton data cannot be compared with hydrographical data from the same points of observation. For ecological studies the centrifuge method and the sedimentation method seem more satisfactory and at present the latter seems to be the best method for obtaining data on as large a fraction of the phytoplankton community as possible. In spite of the high degree of effectiveness of this method so far as most diatoms and armoured dinoflagellates are concerned (HASLE 1953), certain groups are not recorded quantitatively. This is, for instance, the case with the naked *Gymnodiniaceae* which are difficult to identify in the preserved state. At present there is, however, as far as we can see, no better method if one wishes to study phytoplankton ecology in its varied aspects; it is laborious and requires expert knowledge of quite a number of forms, but it seems to be a fairly reliable way of obtaining insight into the plant communities which carry out the immense production of organic matter in the sea.

A detailed study of the phytoplankton vegetation furnishes the background for experimental work on the autecology of the species, a field which may be expected to throw light upon many as yet unexplained phytoplankton phenomena. Only through a combination of ecological studies at sea and experimental work may one be able to obtain an understanding of the highly intricate pattern of plant succession which is observed whenever a region is studied.

One advantage of the sedimentation method is that phytoplankton samples are collected at the same point where observations on temperature, salinity, oxygen and nutrient salts are made. A comparison between the plant population and hydrographical conditions within the same body of water is thus feasible. This is going to be the main theme of our discussion of the results of the microscopical examination of the water samples.

No measurements of plant production are obtained by the method used here. What we record is the composition of the standing crop at the time of collecting and only tentative conclusions may be drawn as to which of the water masses encountered are more productive than others.

b) Factors in phytoplankton growth.

For an enumeration of the factors in phytoplankton production we may refer to the review given by BRAARUD (1935) which, in a slightly modified form, is also to be found in the handbook of SVERDRUP, JOHNSON and FLEMING (1942). When dealing with material collected within a large area at approximately the same time of the year, as in the present case, there are many factors on which we have no data. Supplementary information for parts of the area may be gathered from literature, but a thorough discussion of all factors involved is not feasible, partly on account of the inadequate physico-chemical observations. Consequently we have to restrict ourselves to general considerations where many of the factors in phytoplankton growth are concerned. For the hydrographical conditions data on temperature, salinity

and density give the necessary background. We propose, therefore, to treat the hydrographical aspects of the ecological problems in some detail.

Hydrographically the North Sea is a most heterogeneous area and it is to be expected that the explanation of many of the differences in the phytoplankton may be found in this fact. In the ecological discussion of phytoplankton conditions one hydrographic factor seems to be of outstanding importance, the stability factor, which influences turbulence and thereby indirectly affects the supply of nutrients from deeper levels to the euphotic layer. Turbulence may also cause vertical transport of the population within the euphotic layer or further down into the darker strata and back (Atkins 1925, Braarud and Klem 1931, Hart 1934, Braarud 1935, Gran and Braarud 1935, Steemann Nielsen 1935). The effect of turbulence may be mainly beneficial, mainly detrimental, or neutral to the growth of the phytoplankton community in question, according to its strength and the level of the other factors of growth. Small differences in the turbulence effect cannot be traced as long as so many other factors, which we have no means of determining, vary. We have to be content if we can trace the coarser pattern of the relationship between phytoplankton growth and turbulence as indicated by the stability conditions.

Stability may be characterized with sufficient accuracy by $\frac{d\sigma_t}{dz} \cdot 10^{-3}$ (Sverdrup 1929). The larger this figure is, the larger is the obstacle to turbulent activity within the water mass. On the other hand, even within homogeneous water masses, turbulent activity may vary to a great extent and in that case we have not sufficient observations for estimating it.

Four theoretical cases may be chosen to illustrate extremes in the varied effect of turbulence upon phytoplankton growth:

1) Highly stratified waters, where the discontinuity layer forms a barrier against exchange between the upper layers and the deeper strata. In this case both the beneficial effect of nutrient transport from below and the detrimental effect of a "dilution" of the population through vertical transport are small.

2) Homogeneous waters of great depth, where turbulence may bring up nutrients from the deeper levels while at the same time the population of the euphotic zone is steadily depleted by the water exchange with the deeper layers. Here the positive effect upon the growth of the population, due to the ample supply of nutrients, may be of little actual value if the phytoplankton stock is steadily being reduced.

3) Homogeneous waters of moderate depth, where the bottom is below the euphotic zone. Local decomposition and a steady diffusion from the deposits supplies the bottom layers with products of decomposition, and turbulence carries these from the deep strata up to the euphotic zone. Vertical transport does not reach far down below the zone of photosynthesis and the ultimate detrimental effect of turbulence is not very serious.

4) Homogeneous shallow waters, where the bottom is within the euphotic layer. The bottom is covered with benthic algae (including diatoms) which consume at least part of the nutrients diffusing from the surface of the bottom deposits. In this case turbulence will not be very important in supplying nutrients to the phytoplankton.

The actual effect of turbulence upon nutrient supply and vertical transport cannot be estimated in each case from the hydrographical data obtainable in the present investigation. We hope, nevertheless, through considering the hydrographical conditions in some detail, to be able to trace important features in the ecology of the phytoplankton within the region in question. Our conclusions have to be considered with due reserve in view of the fact that other important factors in phytoplankton growth, such as turbidity, grazing and size of initial stock, which are also influenced by turbulence, may in some cases vary to such an extent as to overshadow the effect of turbulence upon vertical transport of nutrients and phytoplankton dislocation.

In our discussion of the distribution of certain species the ecological effect of temperature and salinity is also going to be considered. The few accessible experimental data on these factors will be mentioned in the following chapters. This also applies to the data on the nutrient salt content.

c) Annual cycle.—Succession and sequence.

When we record a certain population in a water mass, it is as though we were taking a single snapshot out of a steadily changing motion picture. Conditions alter from day to day and a series of factors are steadily affecting the population both in its qualitative and quantitative composition. But, in the same way as a short visit to a terrestrial region may give considerable information on the character of its vegetation, the "scene" recorded from the seasonal cycle of a phytoplankton vegetation may tell us more than the composition of the population at the time of observation; indications as to its history and its future development may also be obtained. The more "scenes" we have, the more accurate will be conclusions drawn as to the dynamics of the vegetation. In the present case only observations from the month of May are at hand. Although we may use observations from other areas and from the same area in other years, we cannot expect too high a degree of certainty in our interpretation of the data in respect to seasonal changes.

In order to have a standard seasonal cycle for reference we may use a hypothetical phytoplankton development similar to that recorded from Norwegian coastal waters, where all-the-year-round observations are available (Gran 1912, 1929, 1930, Braarud and Klem 1931, Ringdal Gaarder 1938, Braarud and Bursa 1939, Braarud and Hope 1952). Minor differences occur, so reference to actual cases is not very useful.

In the dark winter months cooling facilitates vertical mixing, leading to an enrichment of nutrient salts in the surface layers. As light increases a poor winter plankton is succeeded by the characteristic spring diatom vegetation, a succession of a *Thalassiosira*-plankton to a *Chaetoceros*-plankton occurring regularly. These diatom populations dwindle as the nutrient supply is exhausted while the dinoflagellate component increases, with changes in composition, during the summer. A secondary diatom maximum in the autumn may occur, due partly to a more lively supply of nutrients by turbulence (GAARDER 1938), and partly to a reduced grazing (BRAARUD 1944).

There may be several causes of the succession which is especially noticeable in the spring diatom population and in the summer dinoflagellate plankton. The early spring diatoms have been classified as Arctic and the later ones as Boreal (CLEVE 1900c, GRAN 1902, 1912); although it still has to be proved that temperature is the decisive ecological factor in this diatom succession (BRAARUD 1937) there is a society of early spring forms which do not thrive at the time when temperature rises and the characteristic results of stabilization occur. Such species are *Thalassiosira Nordenskioeldi* and *Th. gravida*. The *Chaetoceros* society, which follows, seems to represent a later stage in the succession, before the dinoflagellates take the lead. This is not the place for discussing the various possible factors involved in this succession, but it may be considered to be a typical feature of the phytoplankton cycle in stratified coastal waters of the North Atlantic.

When water masses are compared as to their phytoplankton populations, we may describe societies recorded as being of an "early spring type", meaning that they resemble the early stages of the succession mentioned above, or of a "summer type" if the population is a poor dinoflagellate population. In the following description of the societies encountered in May 1948 we propose to use this terminology for the sake of reference. At certain stations a phytoplankton society was recorded in May, which in Norwegian coastal waters occurs in March—April. In such cases the assumption is made that the succession has not yet reached the same stage as in the stabilized waters at the same season, and that the reason is that the growth of the population—and the accompanying consumption of nutrients—have been retarded. For this reason the early type is still present. Whether the presence of nutrients, the retarded rise in temperature, the absence of metabolic products or other factors are the actual causes we do not know. It may be that the water mass has not yet developed the properties which are prerequisite for the succession to another type of phytoplankton or it may be that the seeding with a proper initial population has not taken place.

For information on the detailed composition of the societies we may refer to the tables for selected stations and the complex tables for the sections (Tables 1—29).

The changes in the composition of the phytoplankton in a certain locality may be due partly to succession within a water mass or to transport of water masses through the area. In the latter case we have a sequence of plant societies (GRAN and BRAARUD 1935, p. 332).

In the North Sea and adjacent waters this feature is of special interest. Atlantic water is steadily streaming into the region from outside, as is Baltic water, and the whole region is characterized by a complex current system. For a study of seasonal changes in a certain locality the problem of sequence is, therefore, of importance. When a method, like the sedimentation method, is used, the data on the hydrographical character of the waters make it possible to discuss bodies of water rather than localities. For other methods, such as the plankton recorder method, sequence is more of a complication when interpreting the plankton data obtained.

d) Previous investigations in the same region.

Since the area of investigation is so complex, a general review of previous investigations of its phytoplankton is not given here. We propose to deal with the main works in a special chapter (p. 29), where a comparison between the conditions in 1948 and those from previous years is attempted. Special investigations are also discussed in Chapter II, where the phytoplankton of the different water masses is treated.

B. Material and Methods.

a) Phytoplankton material.

Samples for quantitative phytoplankton studies were drained from the water bottles directly into bottles of at least 100 ml. and preserved (2 ml. 10% formalin, neutralized with $NaHCO_3$, per 100 ml. sample). At each station samples were collected from 0, 10, 20, (30), and 50 m. and at a few stations in the Færoe-Shetland Channel samples were also collected from deeper levels.

For microscopical examination with the inverted microscope (UTERMÖHL 1931) the contents were thoroughly mixed by shaking and poured into glass cylinders. For the northern sections 2 ml. and 50 ml., and for the southern sections 2 ml. and 10 ml. were counted for each water sample. By means of a HALLER NIELSEN (1950) apparatus a closer study could be made of various specimens after the counting.

The results of the microscopical examination were tabulated. Only selected tables are published here (Tables 13—29) but the complete set of tables is deposited at the Bureau of the International Council for the Exploration of the Sea, where they are accessible. A list of the species recorded is found on page 41. Floristic observations are treated only to a small extent in the present paper. Special observations on the taxonomy and distribution of selected species are being published separately by K. RINGDAL GAARDER

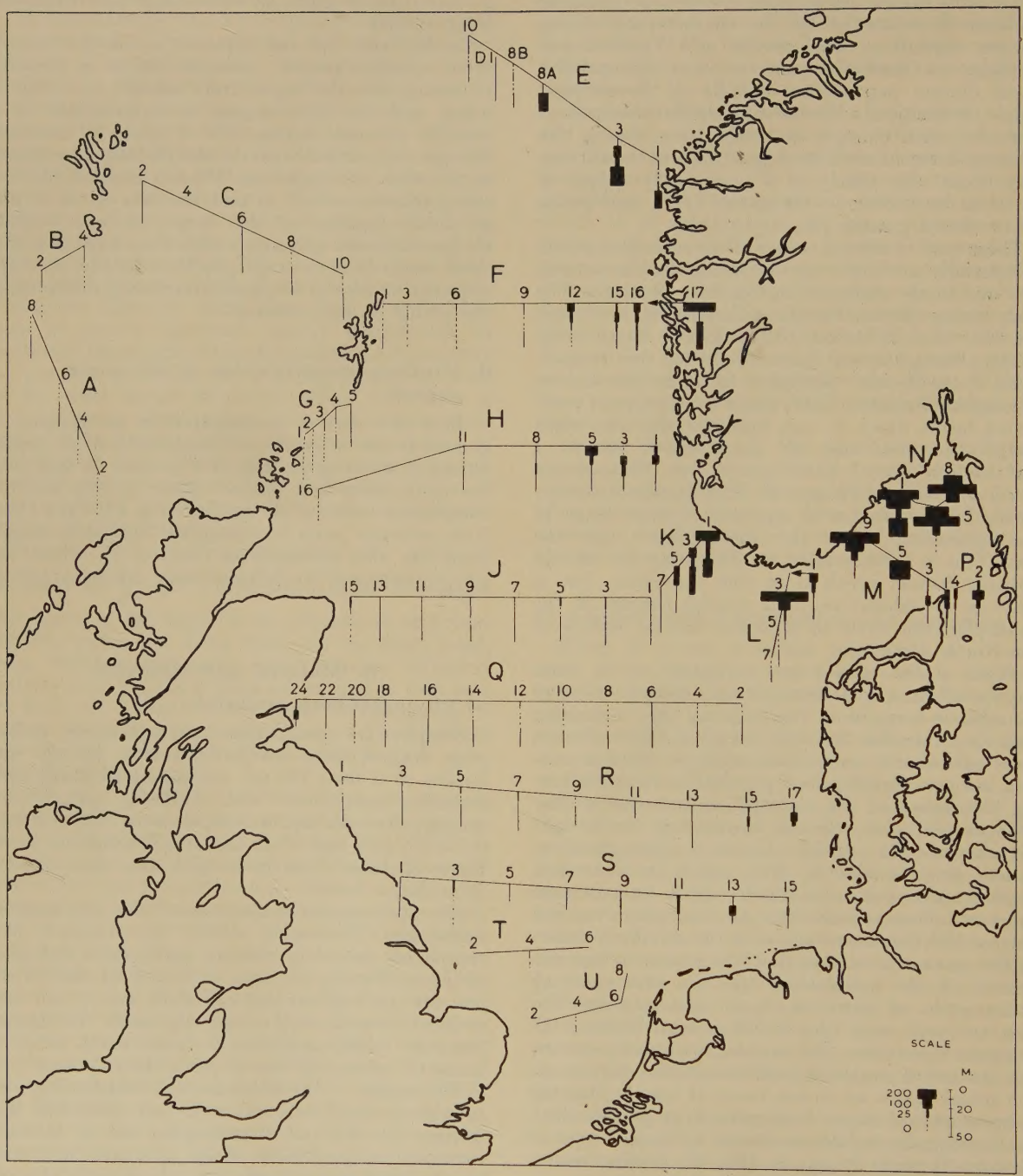

Figure 2. Stability conditions, May 1948, as indicated by $\frac{d\sigma_t}{dz} \cdot 10^3$.

(1953) who, *inter alia*, describes new species of coccolithophorids, and by JUL. GRØNTVED (1951, 1952) who describes a new *Chaetoceros* species (the only sedentary form so far known in this genus) and other observations on diatoms and flagellates as well.

In Figure 1 is found the location of stations where phytoplankton samples were collected. The same station numbers have been used as in the hydrographical investigations.

For all sections tables have been prepared showing the hydrographical data and the occurrence of the more important plankton within the section (Tables 1—12). Instead of discussing conditions within each section we have tried to treat the different water masses separately. The tables, however, are used for reference all through the text, since vertical distribution charts for the important species have not been prepared.

In a list of illustrations (p. 43) reference may be found to horizontal distribution charts for a number of species.

b) Stability conditions.

In order to give the general features of the stability conditions in the region at the time of observation the graphic illustration in Figure 2 has been prepared. The remarkable difference between the eastern part of the region and the rest is clearly brought out. Details on stratification and stability are discussed in the following chapter.

II. The Phytoplankton in Relation to Hydrographic Conditions in May 1948.

The region of investigation has been divided into a number of areas (I—XVI) which are shown in the vegetation chart, Plate A.

A. Phytoplankton Conditions in the Different Areas.

a) The Færoe-Shetland Channel.

Plate A, areas I, II, III.—Tables 1, 2, 13, 14.—Figure 3.

The phytoplankton distribution in this area indicates water masses which, in their nature and distribution, seem to correlate remarkably well with those in a current chart for the same area (TAIT 1937) shown in Figure 6. We are, therefore, using this as a background for our description of the phytoplankton conditions. In Figure 3 the currents in this region are shown according to TAIT's chart and the main distribution of phytoplankton societies is indicated.

1. Inflowing Atlantic water. (I)

Here a poor oceanic vegetation was recorded with coccolithophorids, mainly *Coccolithus Huxleyi*, as the most characteristic members. Besides these the small autotrophic dinoflagellate *Exuviaella baltica* also occurred regularly, but only in small numbers.

The vertical distribution within the upper 50 m. was uniform, as might be expected since the density also was practically the same, indicating turbulent conditions within the current flowing in from the Atlantic.

This type of water filled the whole southern section (A) and also occurred at station B 2, while in the northern section it was found only at the easternmost station (C 10). A tongue of this type of water protruded south of the Shetlands (G 5). The difference between the populations recorded in section A and at C 10, mainly consisting in higher figures for *Exuviaella baltica* at the latter, does not seem to be significant when the geographical distance between them is taken into account.

2. The waters near the Færoes. (III)

In contrast to the poor vegetation of the inflowing Atlantic waters a very rich diatom population was recorded for the waters close to the Færoes. *Thalassiosira gravida*, *Sceletonema costatum*, *Chaetoceros debilis* and other *Chaetoceros* species, *Nitzschia delicatissima*, other diatoms and *Coccolithus Huxleyi* occurred, the last in relatively small numbers (cf. Table 2).

These waters had a slightly lower salinity (35.26 ‰) than the inflowing water masses (35.42 ‰).

To the south of the Færoes, at B 4, the vegetation represented a mixture of that just described and the poor vegetation of the water masses of the Atlantic current.

On the Shetland side of the channel no rich diatom population was observed in our material, but it seems most probable that observations closer to the western side of the Shetland islands might have shown a population similar to that on their eastern side (cf. p. 13).

3. Local Atlantic water (II, C 6 and C 8)

in the central part of the section between the Færoes and Shetland Islands.

Apart from C 10 the stations of the C-section showed influence from waters with a community similar to that recorded near the Færoes. This is indicated by the presence of *Sceletonema costatum*,

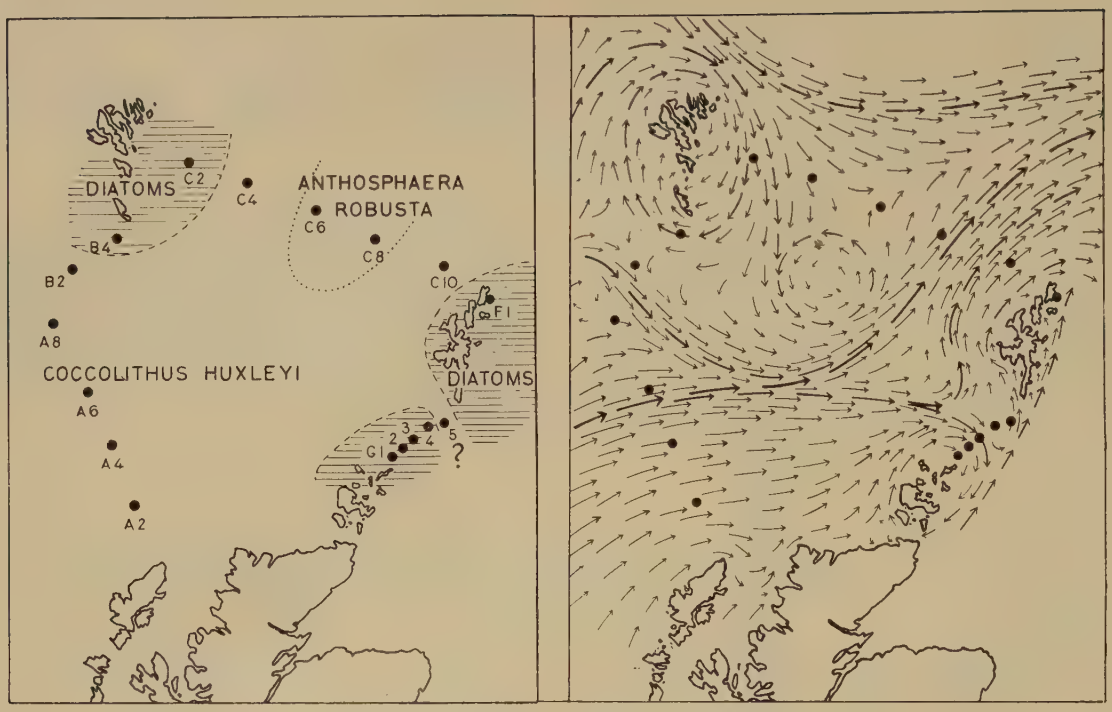

Figure 3. The Færoe-Shetland Channel.

A. Distribution of phytoplankton, indicated by characteristic members of the communities.

B. Surface currents. (From Tait 1937).

Thalassiosira gravida and other diatoms at these stations, all in small numbers only.

The vegetation does, however, demonstrate a definite discontinuity between a central water mass, represented by C 6 and C 8, and the waters occurring at C 4. At the two central stations *Coccolithus Huxleyi* occurred in much higher numbers than at the other stations in the section and, what is more significant, the coccolithophorid *Anthosphaera robusta* at these stations formed an important part of the population while only isolated cells were observed at C 4 and C 2. (Cf. Table 2). This indicates that the central water masses in the northern section, although they are a mixture with components similar to those in the western part, are in a different hydrographical state. Conditions of phytoplankton growth seem to have been more favourable here than in the waters encountered at C 4. There seems to be a natural explanation in Tait's outline of the current system in the region, which shows a cyclonic swirl in this area. Less turbulent conditions may prevail and the unfavourable effects of turbulence be smaller here than outside the swirl.

4. The waters of C 4.

The vegetation recorded at this station indicates that the waters contain a component of the Færoe waters observed at C 2. The population is rather small. The relative proportions of the different species are similar to those at C 2, indicating a fairly recent admixture of the waters containing diatoms. The *Coccolithus Huxleyi* population is much smaller than in the central area and the lack of *Anthosphaera robusta* suggests that the waters of C 4 have received no contribution of importance from the central water mass. Judging from the population alone, the waters at C 4 might well represent a mixture between Atlantic water from the southern section and local Færoe water, but according to the current chart a northerly origin would seem most probable. Since hydrographical data from C 4 are missing, we cannot attempt to reach further conclusions as to the character of this water mass.

The poverty of the population may be due to a high degree of turbulence.

b) The coastal waters of the North Sea.

The areas near the Shetland Islands and the Orkneys, the eastern coast of Scotland and England, as well as the shallow areas near the Dutch, German and Danish coasts are characterized by having diatoms as the predominant members of their plankton. The vegetation of these areas contrasts with the phytoplankton farther away from the coasts, which has a different composition.

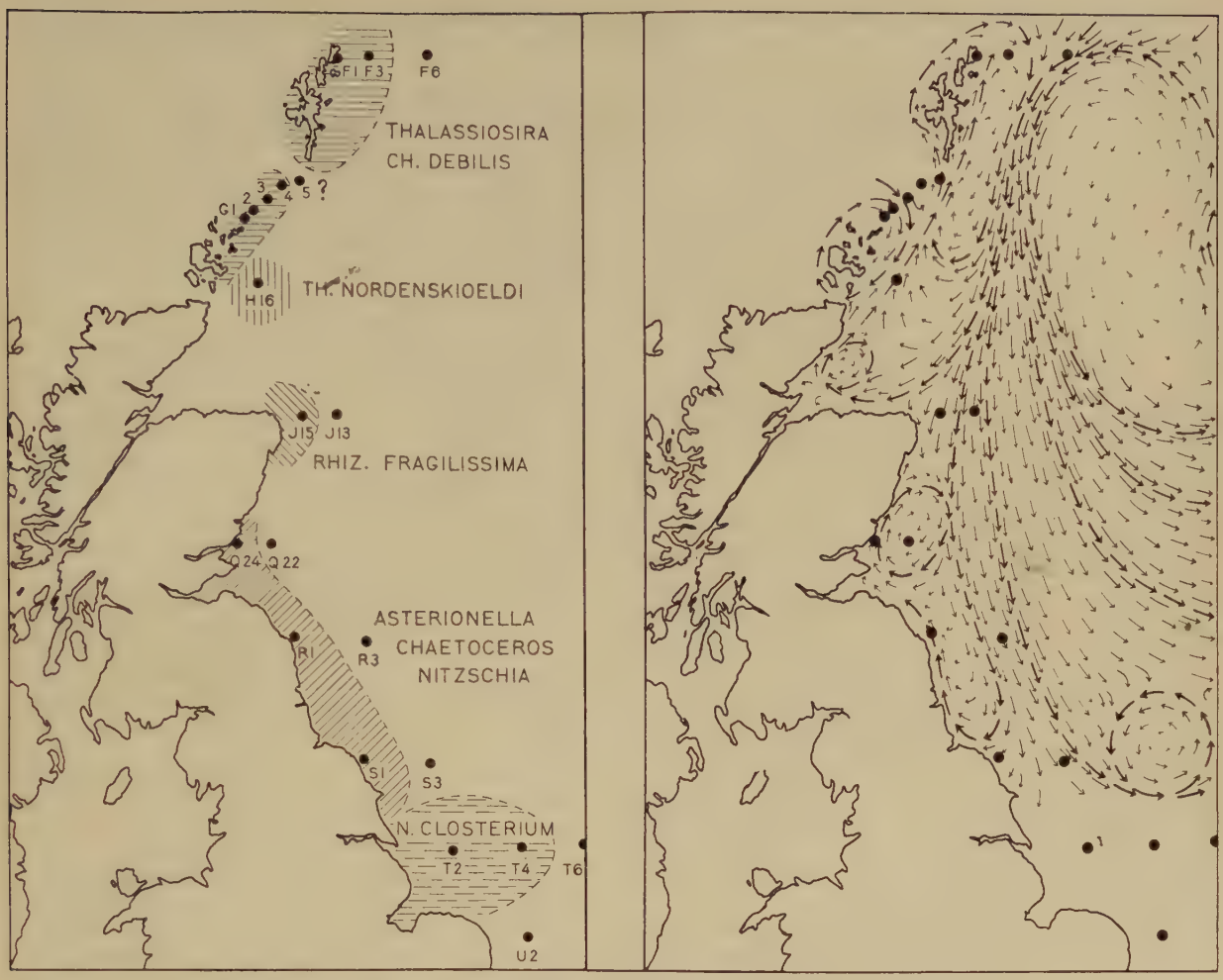

Figure 4. The Shetland-Orkney area and the eastern coast of Great Britain.

A. Distribution of phytoplankton, indicated by characteristic members of the communities.

B. Surface currents. (From Tait 1937).

The diatom populations which are encountered are, however, far from being uniform and we may distinguish different water masses which obviously offer the phytoplankton different conditions of growth. We will first discuss conditions on the western side of the North Sea.

1. The Shetland-Orkney area and the east coast of Great Britain.

Plate A, areas IV–VIII. Figure 4.

In Figure 4 A the various waters where different vegetations were recorded are indicated and in B is shown the current system on the western side of the North Sea according to Tait (1937).

Close to the Shetland Islands (F 1 and F 3 in area IV) a rich diatom vegetation[1]) occurred, similar to that observed at the Færoes. This society consisted of a great number of diatom species of which *Asterionella japonica*, *Chaetoceros debilis* and *C. decipiens*, *Thalassiosira gravida* and *Sceletonema costatum* were especially numerous (cf. Table 4). A similar society occurred at the Orkneys (G 1, G 2 and G 3), the two last stations especially showing an admixture of water from the Atlantic Current with its coccolithophorid vegetation, as observed in the A-section and at G 5.

At H 16 (area V), which is a little farther out, the diatom vegetation was different from those mentioned above. The society indicated that the succession was here in an earlier stage than at the other localities in the same region. Thus *Thalassiosira Nordenskioeldi*,

[1]) The societies described as "diatom vegetations" also include important components of other groups. For details as to their composition cf. Tables 4, 17.

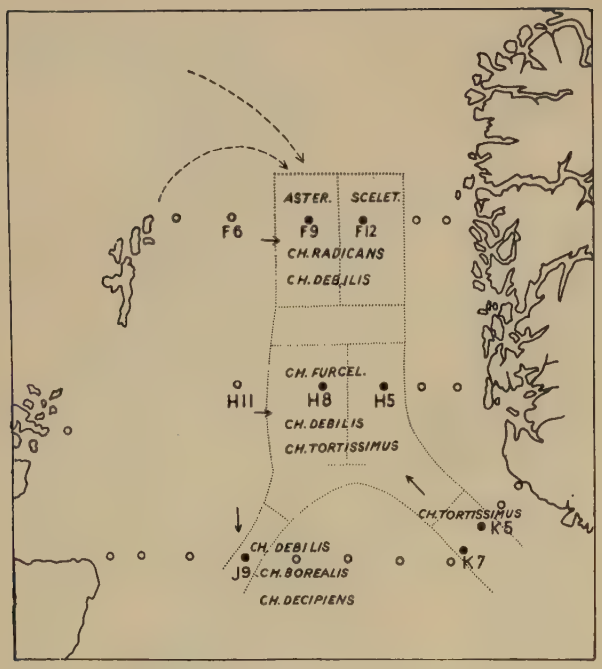

Figure 5. Characteristic diatom species at stations in the northern North Sea. Arrows indicate origin of initial populations. (Cf. Pl. A).

which is regarded as an early spring form, was more prominent here than in the other diatom societies encountered. There was no definite indication of a change towards the later stages of the spring diatom vegetation.

As we pass from the Shetland—Orkney region southward along the eastern coast of Great Britain the vegetations at J 15, Q 24, R 1, S 1 and T 2 and 4 (cf. Fig. 4) clearly indicate that waters of different origin and character are washing the shores.

At the northernmost of these stations, J 15 in area VI, the population was dominated by *Rhizosolenia fragilissima*, a species which was quite unimportant at neighbouring stations to the north as well as to the south. As a matter of fact, this station had a population which stood rather isolated among those recorded along these coasts, nor did it show any definite connection with populations in the offshore waters of the region. On the contrary, there was a discontinuity between the population recorded at J 15 and that of the adjacent station to the east, J 13 where, for instance, *Rhizosolenia fragilissima* was not recorded at all (cf. Table 6).

Going further southwards to area VII we find a very rich diatom population at Q 24 with *Asterionella*, *Chaetoceros* and *Nitzschia* as the leading genera. This vegetation was clearly related to those observed at the stations R 1 and S 1 to the south. The absolute figures for the populations were, however, very different. Also the relative importance of the species varied.

Still further south, in area VIII, the character of the diatom population again changed. *Chaetoceros danicus*, and benthic diatoms mixed with some *Asterionella* gave the character to this vegetation off the Humber and the Wash (T 2). It seemed to be of an estuarine type and it differed from those of the neighbouring stations in all directions. The T 2 plankton was, however, related to the T 4 vegetation, while to the east at the mouth of the English Channel were encountered water masses wherein a different society was present with *Rhizosolenia Stolterfothi*, *Cerataulina Bergoni* and benthic diatoms.

When trying to find the causes for the variety of diatom vegetations in the coastal waters we may make a comparison with Tait's current chart (Fig. 6) and also consider some details in the hydrographical conditions.

The similarity between the vegetations recorded from the Shetland and the Orkney regions may be due partly to the similar hydrographical conditions around these islands and partly to a connection between these water masses, as indicated in the current chart. That the vegetation as late as May was still of the "spring type" may be explained by the fact that the waters are practically homogeneous and turbulence may, therefore, have retarded the succession seriously until the seasonal increase in light made the euphotic layer much thicker than during winter and early spring.

Conditions at H 16 indicate that here the retarding effect of turbulence may have been even more effective than at the other stations. (Cp. also p. 31).

According to the current chart the waters off Rattray Head (J 15) have an origin and direction different from those found farther south. (The vegetation of J 15 may be said to represent a society of species which are characteristic of the late spring and early summer situation.) The high figures for *Rhizosolenia fragilissima* may possibly have been the result of an unusual improvement of the conditions of growth in this water mass, due to an extra supply of nutrients carried up by local turbulence. The vegetation was otherwise of such a type that an admixture of Atlantic waters flowing in from the north is evident (cf. current chart in Fig. 6).

Q 24, R 1 and S 1 are all located in the northgoing drift along the east coast, as indicated in Tait's chart. This explains the similarity in the societies observed. The remarkable difference in the size of the populations may be due to the different hydrographical state of each of the water masses in the three localities. At Q 24 the upper 10 m. were fresher and warmer than the layers below, so a certain degree of stability had been reached. The poor station, R 1, on the other hand, had extremely homogeneous waters, while at S 1 a slight stabilization was again evident. This may be an indication that at R 1 turbulence was extremely strong, so the negative effect upon phytoplankton growth was prevailing, while at S 1 turbulence may have been sufficiently low as to permit the plant

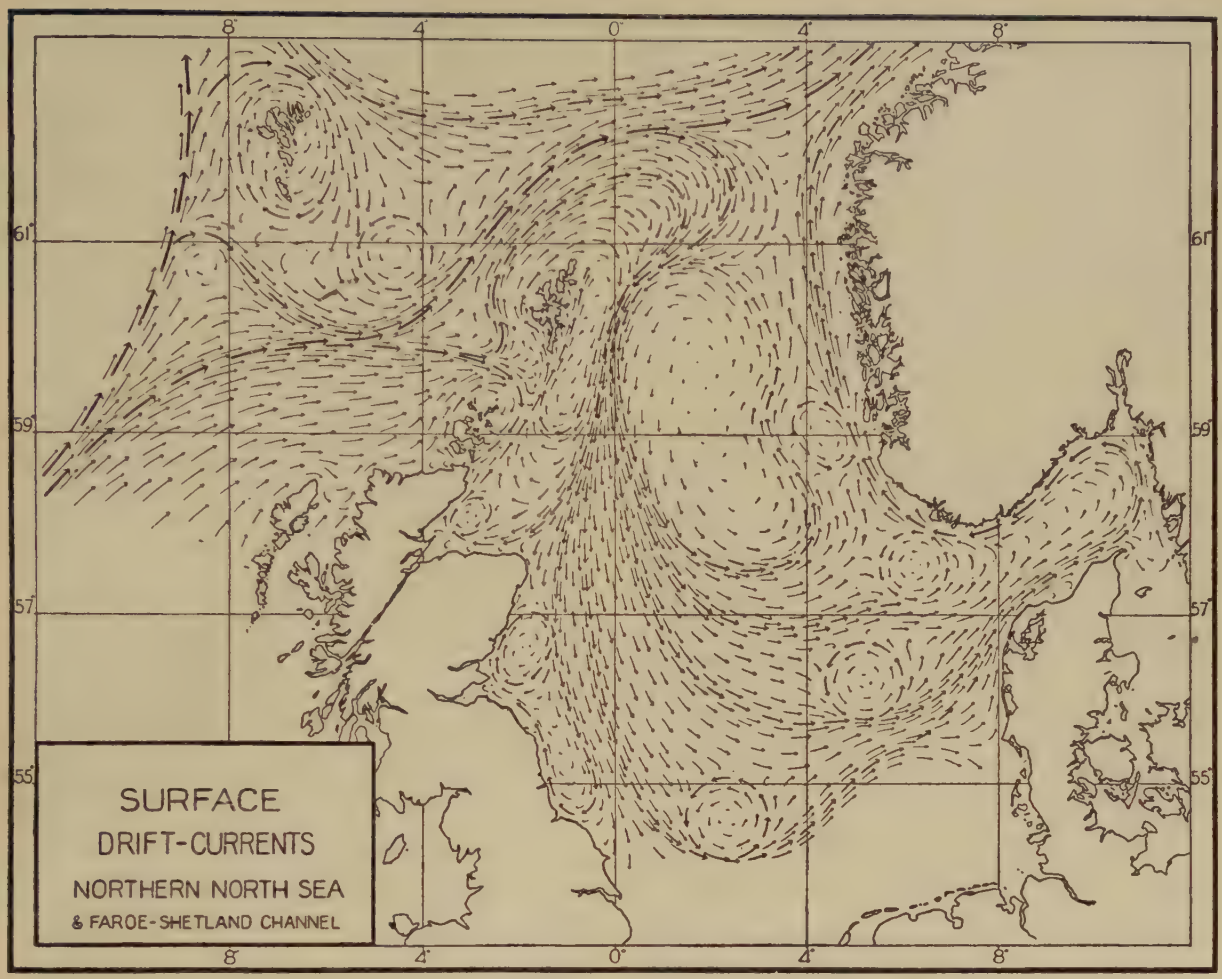

Figure 6. (From Tait 1937).

population to take advantage of a good supply of nutrient salts.

The estuarine character of the vegetation at T 2 seems to be explained by its location just outside the Wash and the Humber.

2. The Southern Bight.

Plate A, area IX. Tables 12 and 21.

The turbulent waters at the mouth of the English Channel had a poor vegetation consisting of a large variety of diatoms and dinoflagellates, all except *Nitzschia closterium* in small numbers. At station U 4 samples were taken at several depths (cf. Table 21). The plankton had an even vertical distribution. At the other stations only surface samples were taken.

The most characteristic feature of this area, apart from its poverty, was the high number of bottom species which were recorded in the plankton. Besides the common *Melosira sulcata* the following species were recorded:—*Bellerochea malleus*, *Biddulphia* spp., *Campylosira cymbelliformis*, *Cymatosira belgica*, *Navicula membranacea* and a number of other bottom forms. The samples were rich in detritus.

3. The south-eastern coastal waters.

Plate A, area X and XI. Tables 10, 11 and 22.

Off the coast of Germany and the western coast of Jutland diatoms were numerous. The society resembled that observed along the East Anglian coast, *Asterionella japonica* and *Chaetoceros debilis* occurring as important components. It is, however, remarkable that on this side of the North Sea *Sceletonema costatum* was not recorded[1]), while on the western side it was such an important species in association with *Asterionella*. In the S-section this type of vegetation was prominent at the easternmost station S 15, while at

[1]) Our observations do not include the waters close to the coast, where the plankton may be different from that recorded here (cf. Wulff 1934; Grøntved 1949).

S 13 and the other stations farther offshore *Cerataulina Bergoni* and *Eucampia zoodiacus* were the characteristic species along with the tychopelagic *Melosira sulcata*. In the R-section, R 15 and R 17 had similar vegetations, but it was rather poor at the latter; both had *Asterionella* and *Chaetoceros debilis* as the most important species. Farther north, observations were not made so close to the coast. At Q 2, which is the easternmost station of the Q-section, a population of *Eucampia* and *Guinardia* was recorded, but it formed no predominant part of the phytoplankton which had a varied composition with all species occurring in small numbers.

In addition to diatoms *Phaeocystis* was common at most of these stations. No quantitative estimate of its abundance has been made.

The hydrographic data seem to give some information relevant to an understanding of the phytoplankton distribution. Starting in the north with Q 2, it will be seen that the main bulk of the diatoms occurred in the deepest sample (46 m.); the upper layers had uniform density, but the deepest sample indicates stratification in salinity and temperature which may explain the great difference in the populations between this and the higher levels.

Stations R 15 and R 17 had well stratified waters and here also the high figures for the important species were recorded from the deeper levels. An explanation of the similarity between the societies recorded at these two stations and at station S 15 may be found in the local current system. BÖHNECKE's current charts (1922) for the month of May 1907 and 1911 both indicate an eddy in this region.

At S 15 and S 13 a certain stabilization had taken place, but the density gradient was not nearly so large as at the two R-stations.

We do not suggest that the actual current conditions in May 1948 in any way conformed with those indicated in BÖHNECKE's chart, but a closer comparison with currents in 1948 is not feasible at present.

4. The Kattegat.

Plate A, area XII. Tables 7 and 23.

At stations M 1, P 2 and P 4 a vegetation was recorded which we may mention here. It consisted of a number of species, among which *Chaetoceros* species were especially predominant at M 1. *Ch. tortissimus* was most numerous.

5. The coastal waters of Norway and Sweden.

Our observations in these waters are discussed in the next chapter in connection with the offshore waters of the North Sea and the Skagerak.

c) The offshore waters of the North Sea and the Skagerak.

In referring to the vegetation chart, Plate A, we will discuss conditions in the offshore waters within the following areas:

1) The Skagerak and the Norwegian coastal current;
2) The northern North Sea;
3) The central area and the Dogger Bank waters.

1. The Skagerak and the Norwegian coastal current:

Plate A, area XII. Tables 5–9 and 24.

We may treat the waters of the Skagerak (the N-section, M 3, M 5, M 9) and the southern part of the Norwegian current (L 1, L 3, L 5, K 1, K 3, H 1, H 3) together, since their hydrographical conditions and vegetation are very similar. Stratification is the most striking hydrographical feature of these waters. Their vegetation was characterized by extreme poverty in diatoms. Only small numbers of *Chaetoceros* (mainly *compressus*), *Nitzschia*, *Leptocylindrus danicus* and *Rhizosolenia fragilissima* occurred at all regularly. The main part of the society was composed of dinoflagellates; *Ceratium* spp., *Exuviaella baltica*, *Peridinium trochoideum* and small gymnodinians were regularly recorded. The gymnodinians were by far the most numerous. *Peridinium trochoideum*, as might be expected of this neritic species, was most abundant at the stations near the Norwegian coast. *Coccolithus Huxleyi* was recorded in small numbers at some of the stations (cf. Fig. 11, p. 25).

A number of small forms could not be identified, numerically they made up the major part of the plankton at some stations; most of them seemed to be heterotrophic. The ciliate *Lohmanniella oviformis* occurred regularly in fair numbers.

The community may be classified as being of a "summer type", similar to that previously known from the same area at this time of the year. Its ecological background was the poverty in nutrients of the surface layers of these stratified waters after the spring diatom maximum.

2. The northern North Sea.

Plate A, areas XV and XVI. Tables 4, 5, 6, 27, 28 and 29. Figure 5.

This area shows a variety of phytoplankton societies and we may distinguish several different water masses, each with its characteristic vegetation.

i) South-flowing Atlantic water. — Area XV.

At F 6 a very poor vegetation was recorded with traces of diatoms and relatively small populations of flagellates, *Coccolithus Huxleyi* and *Exuviaella baltica* being the most important species. The vegetation indicates that here we have oceanic Atlantic water and only very slight admixture with waters containing the characteristic neritic diatom vegetation recorded on either side. Farther south, in the H-, J-, and Q-sections the diatom population was larger, although the numbers were not high, indicating that these water masses had been mixed with adjacent waters. *Chaetoceros* species, mainly *debilis*, *decipiens* and *borealis*, *Thalassiosira bioculata* and *Nitzschia delicatissima* were the most important diatoms. *Exuviaella baltica* was also recorded in rather large populations in the southern part of this flow. The *Coccolithus Huxleyi*

population was not very large at any of these stations.

In the J-section the diatom component was most prominent at J 9, on the border of the poor central area.

Stability increased slightly as one went southward to the J-section from the homogeneous waters encountered at F 6 and the only slightly stratified waters at H 11. The low degree of stability in the northern section may be evidence of a turbulent activity which was so lively as to have hindered the growth of the population. Farther south in the stream stability conditions seemed more favourable and this may have accounted for the larger populations occurring there.

ii) Waters of the mixing area, showing western affinities in their vegetation. — Area XVI.

The water masses in the central part of the F-section had a diatom population which seems to be related to that of the Shetland and the Færoe areas. A great number of species were common to both and at F 9 *Asterionella*, which is so characteristic of the north-western coastal areas, was fairly numerous. Conditions in this area seem, however, to have been very complicated, as one may expect from the hydrographical situation in Tait's chart (Fig. 6). Even the two stations F 9 and F 12 showed remarkable differences in the composition of the vegetation (see Table 4). The main impression is that the waters of both these stations may have had definite western affinities but that they represented water masses which were by no means following the same path. This is also evident from their hydrographical character. F 9 seems to belong to the eastern part of the south-flowing Atlantic water. The difference between the vegetation in the unmixed Atlantic water observed at F 6 (of 35.33 ‰) and the water of F 9 (of 35.31 ‰) was remarkable; it may have been due partly to a more moderate turbulent action at F 9, partly to an admixture of an initial stock of diatoms at this station. The next station to the east, F 12, in contrast to the previous stations, had stratified water where Atlantic water was recorded at 30 and 50 m. In spite of the similarity between the vegetation at this station and at F 9, there were definite differences at all levels so that the impression is gained that the waters here do not represent the mixing product of adjacent waters, but that there is present a local vegetation (note the high figures for *Sceletonema*) such as might be expected if water masses are moving side by side with considerable exchange between them.

iii) Waters with diatom populations showing south-eastern affinities.

In the H-section, to the south of F, vegetations of a type similar to the diatom vegetation mentioned above were encountered at H 8 and H 5. The waters here seem to belong to the great eddy system indicated in Tait's chart. The largest populations were observed at the more western of these stations. *Chaetoceros* was the predominant diatom genus with *Ch. furcellatus* and *Ch. tortissimus* as the most numerous species. These were not recorded from the corresponding stations in the north. Another important feature was the absence of *Asterionella* at these southern stations. This diatom vegetation, therefore, does not seem to have had any direct connection with that recorded in the F-Section. It seems to show some affinity to the diatom population recorded at K 5 and K 7 to the south-east (*Ch. tortissimus*), the explanation of which feature may be found in the general flow indicated in this region by Tait's chart.

A closer net of observation would probably have given us a still more complicated picture of the manifold nature of the vegetation in this mixing area where waters are brought together from so many sources and where conditions of growth for the vegetation may differ within such short distances.

iv) The Norwegian coastal current. — Area XIII.

The waters of this current had the same type of poor dinoflagellate vegetation as was recorded from the Skagerak and the coastal current along the southern coast of Norway. In the K-section this type of water occurred at K 3 and K 1, in the H-section at H 3 and H 1. According to Tait's chart one might have expected to find this type of vegetation also at the corresponding stations in the F-section. This was, however, not the case. Here the current was much narrower, being observed only at station F 16, while the stations on both sides had vegetations which clearly distinguish them as representing different water masses. The situation seems to be extraordinary. At least Gran's observations from 1912 (Gran 1915), which we discuss in detail in a later chapter (p. 29), give no indication of such conditions in May 1912.

v) Norwegian coastal waters inside the coastal current proper.

F 17 represents local Norwegian coastal waters. The vegetation was, however, unusual for this time of the year, *Sceletonema costatum* and *Chaetoceros debilis* having very large populations. In spite of the fact that the surface layers had low salinities (28 ‰) and the waters were highly stratified, the large diatom population indicates an unusually good supply of nutrients. Coastal waters of southern Norway are otherwise known to be depleted of their winter supply of nutrients at this time of the year. The cause of these extraordinary conditions may have been the same as that of the remarkable distribution in the eastern part of the F-section, mentioned above.

vi) Waters on the western side of the Norwegian coastal current.

To the west of the Norwegian coastal current, which was encountered at F 16, there were waters which show definite admixture of Atlantic water, most clearly at a depth of 20 and 30 m. (F 15). They seemed to be of a fairly independent character, probably being part of a current different from that observed at the neighbouring station to the west. Remarkable are the high figures for *Coccolithus Huxleyi* and the predominance of one of the diatoms of the neigh-

bouring diatom vegetation to the west, *Rhizosolenia fragilissima* (cf. Table 4).

The fact that the poor vegetation of the coastal current was recorded only from a very narrow stream in the F-section, seems to be due to extensive turbulence in the complicated current system which we encounter here. The situation illustrated in Tait's chart would not seem adequate in every detail to explain the conditions in May 1948, although the main features of the chart would seem to be in accordance with the observations in the F-section.

3. The central area and the waters on the Dogger Bank.

Plate A, area XIV. Tables 6, 9, 10, 11 and 25.

The central offshore waters of the North Sea in May 1948, had a vegetation in which dinoflagellates were characteristic members; in general it was poor and of a type similar to that found in Norwegian coastal waters when the spring diatom population has dwindled ("summer type").

The following stations showed water of this type:— In the J-section 7, 5, 3, 1, in the Q-section 16, 14, 12, 10, 8, 6, (4), in the R-section 5, 11, 13, in the S-section 5, 9, (11). Superimposed upon this type of vegetation we find remains of a *Rhizosolenia imbricata* var. *Shrubsolei* population which seemed to be drifting to the north-east from the western part of the Dogger Bank region (cf. Fig. 9).

The main feature of the vegetation observed in the central area was the poverty in diatoms and for the most part also in ciliates. The dinoflagellate populations differed somewhat, *Exuviaella baltica* being recorded in varying numbers and the Ceratia occurring rather numerously in some places, mainly in the eastern part of the area. Small forms, probably flagellates (including *Phaeocystis* in many cases), which could not be identified during the counting, were extremely numerous at some of the stations. The heterogeneous nature of this group prevents us from entering upon an analysis of its distribution.

The type of vegetation so closely resembles the dinoflagellate vegetation of stratified waters as described from the Skagerak and the Norwegian coastal current in this survey that a similar ecological background may be assumed. There the lack of nutrient salts seemed to be the cause of the general poverty of the waters. The available data on the nutrient salt content in the central area indicate that there also the cause was the same (cf. p. 20).

Details of the composition of the plankton are to be found in the Tables.

In the Dogger Bank region there was a dinoflagellate population similar to that recorded for the central area. In addition, however, a population of *Rhizosolenia imbricata* var. *Shrubsolei* occurred which is especially noteworthy in view of the many records of *Rhizosolenia styliformis* vegetations from the same area. The largest population was recorded at S 7, while at S 5 the numbers were small. In the R-section R 7 had the largest population. Only a few other diatom species were represented and those only in small numbers.

At the time of observation thermal stratification was evident at all stations in the bank area, but in varying degree. The ecological background for this occurrence of *Rhizosolenia* was the turbulent action in the bank area. For further discussion of this phenomenon see pages 21 and 24.

d) The Norwegian Sea.

Plate A, area II and XIII. Tables 3, 15 and 16.

The stations in the Norwegian Sea were not taken during the same cruise. Stations D 1 and E 8a were worked on 13. May, while E 10, E 8b, E 3 and E 1 were taken a fortnight later. For this reason the whole material from this part must be dealt with separately and cannot be compared with the rest of the observations which were made earlier in May.

The two sets of observations show differences such as may be caused by the advance of the season between the two cruises. We are going to treat them separately.

i) The observations on 13. May. — D 1 and E 8a.

The Atlantic waters observed at these stations represented the main body (E 8a) of the Atlantic current and its fringes along the central Norwegian Sea (D 1). At the former station the salinity was uniform within the upper 50 m. (35.29 $^0/_{00}$), but thermal stratification was noticeable (cf. Table 3). At D 1 a slight stratification in salinity was also evident.

The vegetation at these stations was very similar, except that D 1 had somewhat higher figures for diatoms (*Rhizosolenia fragilissima* and *Thalassiosira* spp.). The vegetation was characterized by fairly large populations of coccolithophorids, *Coccolithus Huxleyi* and *Anthosphaera robusta* being the predominant species. *Exuviaella baltica* was most numerous. A vast number of small forms, which could not be identified, occurred at both with a maximum at 10 m. depth.

ii) The observations on 26.–27. May. — E 10, E 8b, E 3 and E 1.

This section included Atlantic water and Norwegian coastal water. The salinities of the coastal waters at the surface were below 33 $^0/_{00}$. At E 3 there was stratification in the upper water, while at E 1, closest to the coast, the 0, 10 and 20 m. data were practically identical.

The Atlantic waters in this section, observed at E 10 and E 8b, had practically the same kinds of vegetation. It was a rich society with a variety of species (see Tables 15 and 16). Diatoms, dinoflagellates and coccolithophorids were all well represented, like-

wise ciliates and colourless flagellates. Among the diatoms *Rhizosolenia fragilissima, Nitzschia delicatissima, Chaetoceros debilis* and other *Chaetoceros* species, *Eucampia zoodiacus, Thalassiosira gravida* and other *Thalassiosira* species were very numerous. *Corethron hystrix* was present in fairly large populations. Among the dinoflagellates *Exuviaella baltica* was numerous and the coccolithophorids were represented by several species, with *Coccolithus Huxleyi, Anthosphaera robusta* and *Coccolithus pelagicus* as the most numerous.

The vegetation may be characterized as very luxurious. The society was a mixture of oceanic forms, with the southern *Corethron hystrix* and coccolithophorids as characteristic representatives, and neritic forms, such as *Thalassiosira gravida, Chaetoceros debilis* and other species of the same genus.

Oxygen supersaturation was recorded throughout the whole column of water, 0—50 m., in which our observations were made.

Comparing this vegetation with that found on the previous cruise it is striking what a difference there was between the earlier, in which diatoms were quite subordinate and flagellates predominant, and the later, in which both diatom and flagellate populations were very rich.

Current conditions seem to be so complex in this area (Helland-Hansen and Nansen 1909) that we cannot maintain that the same types of water were sampled during the two cruises. On the other hand observations from the Atlantic current farther south (Steemann Nielsen 1935) and from the Weather Ship M farther north in the Norwegian Sea (Halldal 1953) have shown that just at this time of the year a rapid development of phytoplankton takes place in the Atlantic water masses. The main cause of the change in vegetation from the 13. May-cruise to the next may, therefore, be the seasonal changes in the vegetation of the Atlantic waters.

The vegetation of the Norwegian coastal current (E 3 and E 1) consisted mainly of flagellates. Diatoms were extremely scarce. Of the dinoflagellates *Exuviaella baltica* was fairly numerous and Ceratia had larger populations here than in the Atlantic part of the section, just as in the North Sea (cf. Fig. 13, page 26).

One feature stood out and distinguished this type of vegetation from that recorded in the Norwegian coastal waters farther to the south—the large populations of *Coccolithus Huxleyi*. These seem to be the result of seeding by admixture of waters from the border of the Norwegian Atlantic current. The more advanced season, with higher temperatures, would account for the relatively high figures (1,250,000 per litre at 20 m., E 3). A t-S-diagram for E 3 indicates influence from Atlantic water at this level.

B. The Main Features of Phytoplankton Distribution in Relation to Hydrographic Conditions, May 1948.

The phytoplankton in the various areas having been dealt with in some detail, we will now review conditions in the main bodies of water.

When trying to obtain some insight into the interaction of ecological factors which results in the highly varied phytoplankton communities recorded, we may avail ourselves of data on nutrient salt distribution. In the present survey analyses of nitrate and phosphate content were carried out for the Q-, R- and S-sections only. Previous investigations in the North Sea deal mostly with limited areas (Atkins 1925, 1928, Schreiber 1927, Seiwell 1931, Kalle 1933, Buch 1934, Graham and Harding 1938, Grøntved 1952), but Thomsen (1933) has given a more extensive report on nitrate and phosphate distribution in the central and southern North Sea. His observations were made in the beginning of May and are, therefore, especially useful as a background for the present discussion, in spite of the fact that they were carried out in 1932.

The waters of the North Sea proper may be referred to different categories, according to the purpose of the discussion. Here we are going to treat the following water masses separately: a) Atlantic water from the north, b) North Sea water of Atlantic origin, c) Channel water, including Atlantic water from the south, d) coastal waters, including the Skagerak and the Norwegian coastal current and e) waters of the border areas. The Norwegian Sea (f) is treated separately.

a) Atlantic water flowing in from the north.

The Atlantic water running into the Færoe-Shetland Channel is a turbulent water mass which, in May, had a poor flagellate vegetation dominated by *Coccolithus Huxleyi* and *Exuviaella baltica*, evenly distributed within the upper 50 m. (as deep as most of our observations go). The content of nutrient salts may be assumed to be high (Atkins 1928, Seiwell 1931, Steemann Nielsen 1935, Dana-records from 1946—48[1])). When this water mass enters the Norwegian Sea it branches and one main flow turns southwards into the North Sea. This south-flowing Atlantic water was still very turbulent and the vegetation was poor, similar to the original one. On passing southwards, these waters receive some admixture of water masses along their edges and the turbulence gradually becomes less pronounced. At the same time the vegetation increases. It consists partly of the same species as before, partly of diatom populations which presumably have developed on the basis of an initial stock introduced through mixing with the adjacent waters. In the western part of the flow the diatoms in May played a subordinate role as compared with the

[1]) According to information kindly given us by the Council's "Service Hydrographique".

flagellate component, which was of a composition similar to that recorded in the inflowing waters (*Coccolithus* and *Exuviaella*). In its eastern part diatoms were more prominent.

When trying to trace the influence of the original vegetation of the inflowing waters within the southern part of the flow we are handicapped by lack of information on some pertinent points which we will mention.

The vegetation of the Atlantic current is apt to show seasonal variation. Steemann Nielsen (1935) has shown that in April 1934 the vegetation was extremely poor, while from May onwards a rich flagellate population occurred with *Coccolithus Huxleyi* as the leading species. If the original populations of the waters flowing into the North Sea contain large quantities of coccolithophorids, as during summer-autumn, these may be expected to form an important part of the plankton of the south-flowing stream in the northern North Sea. If, at other times, the original population is very small, coccolithophorids may play only a small part in the phytoplankton farther south. (In May 1948, the part played by coccolithophorids was not very great.)

When recording the phytoplankton distribution within the whole area at a certain time, we encounter Atlantic water masses of different "age". These may, when they entered the North Sea, have had very different original populations, according to the season. Consequently the Atlantic components in their vegetation later on may be very different according to the differences in seeding by the inflowing waters. The seeding with neritic populations from the adjacent waters may also vary for the same reason.

Even if we had known the seasonal changes in the composition of the phytoplankton entering in the north it might not have sufficed for a detailed analysis of the situation recorded in May 1948. In order to evaluate fully such information we would also need data on the speed at which the Atlantic waters were flowing down from the north and spreading over the various parts of the area. This has to be kept in mind when discussing conditions in the various waters with Atlantic components.

b) North Sea water of Atlantic origin.

The transition from the waters entering in the north to the waters of the central part is not easily understood, even in view of the current conditions as indicated in Tait's chart. In May 1948, there was a discontinuity between the fairly rich main branch of inflowing waters (as represented in section J, see Table 6) and the waters of the central part. This is not readily explained if a fairly regular flow, as indicated in the current chart, is assumed.

Thomsen's observations in May 1932 show that even at the 25 m. level nitrate was completely consumed (Thomsen 1933). At the 50 m. level, zero nitrate values were also found in most parts of the central area, high values being recorded only in the northern part. Results of analyses from the present survey are similar to Thomsen's findings.

These data on nutrient salts corroborate the picture obtained from the phytoplankton distribution of water masses which, in respect to nutrient supply, are in a state similar to the summer condition in stratified coastal waters. However, the central water masses in May 1948, showed only a slight thermal stratification and stability was still little pronounced. In spite of the small density gradients in these waters, turbulence must have been insufficient for any considerable vertical transport of nutrients. The central area, according to these observations from May, would seem to represent a water mass with restricted turbulent activity, possibly having a slow flow. It may have the character of an eddy.

Although it may not have been the intention of the author, Tait's chart conveys the impression of an even flow of northern Atlantic water into the central areas (cf. Fig. 6). The phytoplankton distribution gives a different picture. There is a contrast between a main western flow of Atlantic water, where a fairly even change in the plankton is observed towards the south, and a central, presumably more slowly moving, possibly eddying, water mass of remarkable ecological uniformity. It is premature to make any definite statement on the basis of the available plankton material alone, but there seems to be some support for such an interpretation in Böhnecke's current chart for May 1911 (Böhnecke 1922).

The differences in the composition of the vegetation within the western flow, especially as to the part which *Coccolithus Huxleyi* plays, may be explained by the different "age" of the Atlantic component. Water which entered during winter and early spring presumably was very poor in *Coccolithus Huxleyi*. Such water may be found off the English coast in the month of May. Here *Coccolithus* was found in fairly large numbers in the northern J-section, and in very low or zero quantities farther south (Q-, R- and S-sections).

In the shallower parts vertical mixing during winter supplies the whole water column with nutrients originating partly from the bottom deposits. In the deeper parts supplies from the rich layers below the photosynthetic zone are brought up during the winter. In early spring a diatom population avails itself of these nutrients. Knowledge of the conditions at this time of the year and also as to the qualitative composition of the phytoplankton, is incomplete (Cleve 1897 etc., Wulff 1925, Lucas 1941, Grøntved 1952). As soon as a certain degree of stabilization is reached, the vertical transport of nutrients is slowed down. Parallel to this process the diatom vegetation is gradually succeeded by a flagellate community which, according to our May records, is very poor. Lucas (1941, p. 39), on the basis of his plankton recorder survey, states that "after a period in which diatoms were fairly widespread over the central waters of the North Sea, they became progressively scarcer there from May onwards, the summer patches being on the

whole more coastal and, of course, thinner ... it was not until October and November that they became relatively significant in the central waters again." The occurrence of a local diatom population at the 40 (50) m. level in the isolated patch of cold water in the north-eastern part (Q 4, 6, 8) may represent the last of the spring diatom population in this central area.

In certain localities, however, the bottom configuration leads to an upwelling of deeper waters, even in May and later, accompanied by turbulence. Such processes generally are observed near banks where the bottom shoals (Bigelow 1927). In the North Sea the Dogger Bank is known to be such an area. Phosphate records demonstrate this feature quite well (Graham 1938) and earlier phytoplankton records have given ample evidence of the occurrence of dense patches of diatoms near this shallow region (Savage and Hardy 1935, Savage and Wimpenny 1936, Lucas 1941).

This bank effect is also demonstrated in our material, *Rhizosolenia imbricata* var. *Shrubsolei* occurred in fairly large populations over the western part of Dogger and a drift towards north-east was indicated by the distribution of this vegetation (cf. Fig. 9).

c) English Channel water (including inflowing water from the south).

Channel water proper may not have been recorded at our stations, but the vegetation of the Southern Bight was so different from that in the adjacent areas that one may assume that it was closely related to the vegetation occurring in the Channel. These water masses were decidedly not Atlantic, the salinity being below 35 $^0/_{00}$. They were practically homogeneous and the vegetation was a poor diatom vegetation. There is one remarkable feature which seems significant relative to the influx of water from the west through this entrance to the North Sea:—in the northern North Sea coccolithophorids are characteristic of the inflowing Atlantic waters, *Coccolithus Huxleyi* being the most numerous species, but this type of vegetation was not observed at all in the southernmost part (cf. Fig. 11); the whole southern North Sea was devoid of this vegetation apart from a few cells recorded along the Flemish coast. This would indicate that, assuming the Atlantic water masses to the west of the Channel have a vegetation similar to that in the north, no effective influx of Atlantic water through the English Channel had taken place for quite a long period of time.

The problem of the influx through the Channel is discussed somewhat more extensively in another chapter (p. 33).

d) Coastal waters, including the Skagerak and the Norwegian coastal current.

The coastal waters around the North Sea offer the phytoplankton such different conditions of growth that a review of all the types of habitat encountered is not feasible here. Only some general features will be pointed out.

There is a remarkable difference between a western group on one side represented by the coastal waters of the Færoes, the Shetlands, the Orkneys and northern Great Britain, and an eastern group on the other, including waters of the eastern coasts of the North Sea. The two groups of habitats differ in various ways. The following seem to be salient features:— the coastal waters near the islands in the north and Scotland are of Atlantic character, for two reasons, (1) the close connection with inflowing Atlantic water and (2) the small discharge of freshwater from land, owing to the restricted areas of precipitation. The chances of establishing stratification are much smaller here than in areas with large supplies of freshwater. Strong tidal currents and the active Atlantic current system in the western neighbourhood also act in the same direction against the forces producing stable stratification (cf. Dietrich 1950).

The other group of coastal waters, including parts of the continental coasts of Central Europe, Denmark and the Scandinavian coasts, is characterized by having large quantities of freshwater discharged by rivers draining the continental areas. This freshwater discharge increases the possibilities of establishing stratification in the spring. We might also assign local water masses along the English coast outside the mouths of the large rivers to this type, but strong tidal currents may effectively counteract the forces of stabilization as also happens in parts of the south-eastern areas (cf. Dietrich 1950, Fig. 10).

This is a coarse grouping of the coastal habitats. Other physical factors besides stabilization, especially turbidity and various other ecological factors, interact, so that a diversity of habitats with characteristic vegetations are found within each of these groups.

Generally speaking it may be stated that the phytoplankton conditions within these two groups are different at all seasons of the year. In the western and part of the south-eastern habitats stable stratification is not attained in spring and the spring diatom growth is retarded as compared with that in the north-eastern habitats, where stratification is established early. Our observations in May exemplify the variety of vegetations which for these reasons may be observed around the shores of the North Sea, ranging from the early spring type with different stages in the succession of diatom vegetations to the poor dinoflagellate vegetation of the summer type.

e) The border areas.

Exceptional conditions usually prevail where water masses of different current systems meet. In the present material the following examples may be mentioned: L 7, K 5 and K 7, F 15.

L 7 is located in the North Sea proper near the Skagerak and the Norwegian coastal current. A local abundance of *Exuviaella baltica* indicated that due

to turbulent activity a somewhat richer supply of nutrient salts may be found here than in the water masses on either side. The salinity distribution supports such an assumption.

The stations K 5 and K 7 are located in an area where the isohalines are crowded, which is a sign of its transitional character. These two stations had a diatom population which was markedly richer than those of the neighbouring stations on both sides.

At F 15 a branch of Atlantic water, penetrating from the north at a level of 20—30 m., was noticeable. The effect of this water mass is seen in the character of the vegetation as well as in the size of the population. *Coccolithus Huxleyi* was a prominent member of the phytoplankton.

If a denser net of observations had been available, many other similar cases might have been recorded. Those mentioned may suffice to demonstrate how extraordinary local hydrographical conditions coincide with exceptional features in the vegetation, and indicate the manifold ecological effect of the hydrographic state of the waters upon phytoplankton.

f) The Norwegian Sea.

The southern part of the Norwegian Sea, where observations were made during the present survey, is dominated by Atlantic waters arriving partly through the Færoe-Shetland Channel and partly from north of the Færoes. The hydrographic state of the various parts of the current system and the admixture of other waters are so variable that it is difficult to give a general characterization of the whole area.

Coccolithophorids are characteristic members of the vegetation at this time of the year, but neritic components, the origin of which is difficult to trace with the present material, were present. The possibility of contributions from the coastal waters around the Færoes, from waters in the Icelandic area and from the Norwegian coastal current may be suggested, but a closer study of conditions in this area has to be made. Halldal (1953) in his study of the annual phytoplankton cycle at position M farther north has given a background for a more extensive survey of the Norwegian Sea. Since work of this nature is being planned in the near future we refrain from a more detailed discussion of the phytoplankton conditions in the southern Norwegian Sea.

C. The Distribution of the Phytoplankton Species.

In order to give some characteristic examples of distribution of the phytoplankton species in May 1948, we are going to deal with the following:—*Asterionella japonica, Nitzschia delicatissima, Rhizosolenia imbricata* var. *Shrubsolei, Anthosphaera robusta, Coccolithus Huxleyi, Exuviaella baltica* and *Ceratium* spp. — Additional information may be found in the composite Tables 1—12.

Two main causes of a phytoplankton species exhibiting an uneven distribution within an area may be pointed out: 1) the different possibilities in the various water masses for the growth of the species in question, 2) different supplies of initial stock to the various parts of the area. The examples given below demonstrate how in some cases the first factor seems to be decisive, as in species which have a wide and general distribution throughout the area, and in other cases the supply of an initial population of local or distant (oceanic) origin seems to be mainly responsible for the species distribution. In the latter case conditions of growth also influence the relative abundance of the species.

a) Diatoms.

Asterionella japonica Cleve.

This species represents an interesting type of phytoplankton organisms. Ostenfeld (1913) and Gran (1929) have summarized its general distribution in Northern waters. It occurs in coastal waters in the western and southern parts of the area, while in the eastern and northern parts its occurrence is more capricious. It may also occur in the central part of the North Sea (Lucas 1941 and Grøntved 1952).

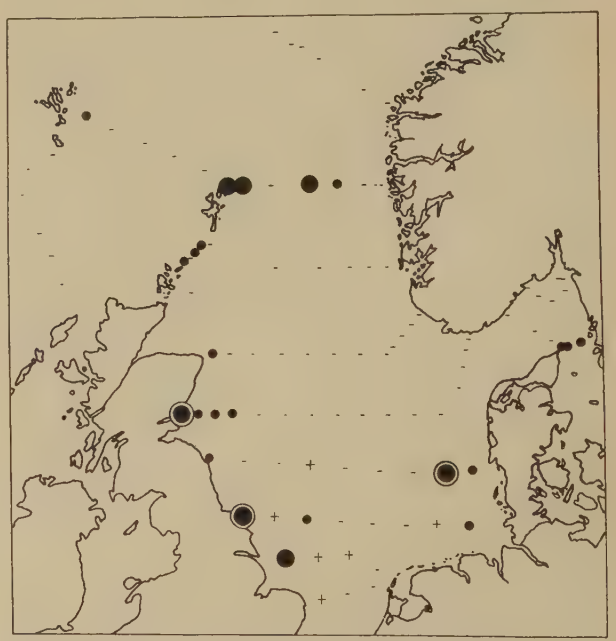

Figure 7. *Asterionella japonica.* Distribution in May 1948. Maximum numbers at each station (cells per litre).
+ 0— 1,000 ● 10,001—100,000
• 1,001—10,000 ◉ 100,001—

Its distribution in May 1948, was in agreement with these older observations. It may be pointed out, however, that during the 1912-survey it was recorded only from one station, east of Shetland; in recent

years it has been more generally distributed (cf. Gran 1929, Steemann Nielsen 1935, Lucas 1941).

Gran (1902) characterized *Asterionella japonica* as being temperate-atlantic-neritic. Its irregular occurrence in the area of investigation may be explained by the fact that it belongs to the group of neritic phytoplankton species which, as far as we know, do not form special resting stages.

Species which are able to form cysts may occur only for a short period of time in the plankton while during the rest of the year they survive as cysts which germinate in due course. These species may, however, be recorded regularly in the same area, year after year.

Species which do not form cysts may, on the other hand, occur more irregularly. In order to maintain a stock from one year to another, conditions for growth must be reasonably good throughout the whole year. If so, a certain population may survive all seasons, although the species attains abundance only at certain times of the year. In areas which offer such conditions the species occurs as a regular member of the local plankton. In other areas, however, conditions for growth may be too poor at certain seasons for the population to survive. Here the occurrence of the species is dependent upon a supply of an initial population from other areas, which supply may vary

Figure 8. *Nitzschia delicatissima*. Distribution in May 1948. Maximum numbers at each station (cells per litre).
+ 0— 1,000 ● 10,001—100,000
• 1,001—10,000 ◉ 100,001—

from year to year according to changes in the circulation of the water masses. To this group we may refer *Asterionella japonica*.

In the Færoe-Shetland region and along the southern coasts of the North Sea *Asterionella japonica* is a regular member of the plankton. Its abundance may be somewhat irregular here too, but conditions of growth may be sufficiently good during the whole year for maintenance of a stock. This may be attributed to the fact that in these areas turbulent action leads to a sufficient supply of nutrients to the euphotic layer. In other areas, such as Norwegian coastal waters, stabilization is so pronounced during a long period of the year that the nutrient supply is too small for diatom growth. In such areas the occurrence of *Asterionella japonica* is dependent upon introduction of an initial population from outside at the time favourable for growth (cf. Gran 1929). Although insufficient nutrient supply during the summer may be decisive in most cases for the disappearance of *Asterionella* from these waters, other possibilities have to be mentioned also; unfavourable temperature conditions and the mutual influence of phytoplankton species may also play a part.

Other species which belong to this group, such as *Guinardia flaccida*, and *Sceletonema costatum*, may have distributions different from that of *Asterionella japonica*, presumably on account of differences in other ecological characters.

Nitzschia delicatissima Cleve.

Fig. 8.

Quantitative investigations by Gran (1915) and Steemann Nielsen (1935) have demonstrated how important this small species is in the plankton of the Atlantic waters south of Iceland, in the Irminger Sea, around the Færoes and in the southern part of the Norwegian Sea. During the 1912-survey of our area (Gran 1915) it was found to be the commonest of all diatoms.

In the 1948-material the species was also common, and at some stations occurred in high numbers. As in 1912 the largest populations were observed in communities where neritic species formed an important part (cf. Tables 1—12). Since the species has such a wide distribution, the occurrence of large populations would seem to be mainly a question of favourable conditions of growth. Only at a few stations, most of which were located in the central area and in the Norwegian coastal current where in May conditions for diatom growth were obviously poor, was it missing from the records.

The ecology of this species is still obscure. It thrives in the Atlantic water masses of the region, but may also occur in quantity in coastal waters (Gran and Braarud 1935, Braarud, Føyn and Rytter Hasle 1953).

Gran (1915) suggested that *N. delicatissima* may be a modification of *N. seriata* but this has yet to be proved. It would seem very desirable to obtain information on taxonomical and ecological problems in these species by means of cultures; they have both been found to grow well with the usual technique (Braarud unpubl.).

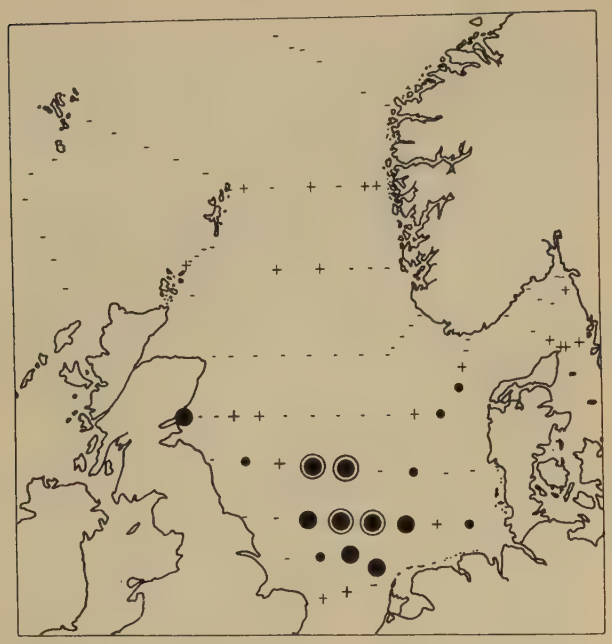

Figure 9. *Rhizosolenia imbricata* var. *Shrubsolei*. Distribution in May 1948. Maximum numbers at each station (cells per litre).
+ 0— 500 ● 1,001—5,000
• 501—1,000 ◉ 5,001—

Figure 10. *Anthosphaera robusta*. Distribution in May 1948. Maximum numbers at each station (cells per litre).
+ 0—1,000 ● 5,001—25,000
• 1,001—5,000 ◉ 25,001—

Rhizosolenia imbricata var. *Shrubsolei* (Cl.) Schröd.

Fig. 9.

Ostenfeld (1913) somewhat hesitatingly classifies this species as oceanic, although it occurs most abundantly near the coasts. Its main distribution seems to be in the southern North Sea and the English Channel (Ostenfeld 1913, Gran 1915, 1929, Wimpenny 1933, Lucas 1940, 1941, Grøntved 1949). It has been recorded from the Færoe region and the coast of Norway, but only in small numbers.

In our material its centre of distribution was the Dogger Bank area, while a much poorer vegetation was recorded to the north-east of this area, in the direction of the general drift of the waters.

In view of the interesting observations on patches of *Rhizosolenia styliformis* in the Dogger Bank area in connection with herring investigations (Savage and Hardy 1935, Savage and Wimpenny 1936, Graham 1938) the occurrence of another *Rhizosolenia* in the same area is noteworthy.

The hydrographical background for the occurrence of such a numerous population of this large diatom in an area which otherwise had a poor dinoflagellate plankton seems to be that the Dogger Bank, representing an obstacle to the flow of water, leads to a turbulent activity which is sufficient to supply nutrients from deep waters (Graham 1938). According to Graham these nutrients originate partly in Atlantic water entering from the north and partly in local deep waters. Which physiological or ecological factors are responsible for the prevalence of these *Rhizosolenia* species in the area we cannot say; too little is known as yet of diatom autecology.

b) Coccolithophorids.

Anthosphaera robusta (Lohm.) Kamptner.

Fig. 10.

The distribution of this species seems to conform mostly to that of *Coccolithus Huxleyi* as it is described below, but not in every detail. It was not recorded from the inflowing Atlantic water in the southern section of the Færoe-Shetland Channel, where *Coccolithus Huxleyi* formed a characteristic component of the plankton. The two species had a similar distribution in the Norwegian Sea, while in the North Sea proper there were again certain divergences, for instance in the Rattray Head area. These were, however, not enough to change the general impression that these two most numerous coccolithophorids have their main distribution in Atlantic water or in water with a recent Atlantic component (cf. also below).

Coccolithus (Pontosphaera) Huxleyi (Lohm.) Kamptner.

Fig. 11.

Before discussing the distribution of this species a few remarks may be made on its taxonomy. Since Lohmann (1902) described *Pontosphaera Huxleyi*, a

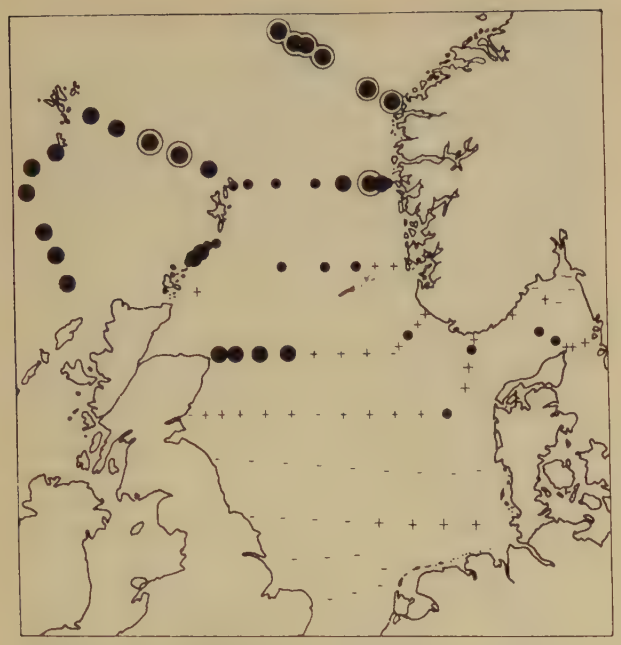

Figure 11. *Coccolithus Huxleyi*. Distribution in May 1948. Maximum numbers at each station (cells per litre).
+ 0— 5,000 ● 25,001—125,000
• 5,001—25,000 ⊙ 125,001—

number of quantitative investigations (Lohmann 1920, Hentschel 1936, Böhnecke, Føyn, Waitenberg 1932, Steemann Nielsen 1935, Gran and Braarud 1935, Ringdal Gaarder 1938, Braarud 1945) have recorded it from all parts of the Atlantic, from the Antarctic to the Tromsø region, from the most typical oceanic localities to the innermost parts of fjords where the highest numbers have been recorded. Since Kamptner (1943) showed that possibly at least three taxonomical units have been recorded as *Pontosphaera Huxleyi* Lohm., one of them being *Coccolithus Huxleyi* (Lohmann) Kamptner, the older records have to be treated with this fact in mind. Future investigations have to decide whether the entire Atlantic *Pontosphaera Huxleyi* population consists of *Coccolithus Huxleyi* or whether it contains also other forms described by Kamptner.

Only a few of the cells recorded during our survey have been examined at such high power that definite identification of them as true *Coccolithus Huxleyi*-specimens could be made; all the cells examined more closely had, however, the characteristic coccoliths of this species. Until evidence is found for the occurrence in this region also of the other forms described by Kamptner, we may assume that not only our records but also the older *Pontosphaera* records from North Atlantic localities, involve *Coccolithus Huxleyi*.

If we try to find the background for its distribution in May, as shown in Figure 11, the lack of definite information on its ecology makes analysis difficult. Since no experimental data are as yet available as to the temperature and salinity effect upon the growth of this species, only biogeographical data are at hand for possible information on this point. Lohmann (1920), on the basis of its occurrence in the western Baltic, found that it reached its highest frequency at 15—16° C and that it disappeared completely when the temperature fell below 7° C. It would, however, now seem that Lohmann's conclusion as to the temperature dependency of this species was not too well founded. Other factors of growth may have been decisive for the seasonal change in the population. In this connection it is interesting to note that the maximum population within our area in early May, 337,500 cells per litre, was observed in water masses of 7.9° C.

The distribution in May 1948, indicates that *Coccolithus Huxleyi* is characteristic of the Atlantic water masses flowing into the area through the Færoe-Shetland Channel at this time of the year. Furthermore it is found in even larger populations in "older" Atlantic water in the southern part of the Norwegian Sea, and it is a regular member of the waters of the Northern North Sea in which admixture of Atlantic water has taken place. In the southern part of the North Sea and the Norwegian coastal current south of Bergen it is sparse or lacking.

The origin of the populations which were observed in the north must have been Atlantic water which had recently entered the area. Judging from the distribution chart no stock of any considerable size seemed to have survived the winter in the main part of the North Sea. This does not exclude the possibility of a very scattered population of autochthonous character being present, which might, at a later stage in the season, increase and form the basis of a larger population.

In May its distribution definitely indicates an allochthonous origin of the main *Coccolithus Huxleyi* population of the region.

The allochthonous population would also seem to have by far the best opportunity of growing into a large population at this time of the year. Atlantic water masses, which contain *Coccolithus Huxleyi*, are also rich in nutrients. After entering the area considerable parts at least of these water masses become less turbulent, the light supply increases with the season and conditions for phytoplankton growth are thus improved. The population present may, therefore, have a good chance of rapid growth. (In mixed water masses the population of the other mixing component may compete and possibly take the lead).

An autochthonous *C. Huxleyi* population may, on the other hand, be found in the old waters of the area, where the local diatom population has used the nutrient supply before the temperature reached a level which would allow a good growth of *Coccolithus*. When temperature becomes sufficiently high (as in May—June) *Coccolithus* may in most parts of the North Sea be hampered in its growth by the lack of nutrients.

Experimental studies of this species may reveal important features in its autecology. In addition to

studies on temperature and salinity effect upon growth, information on the light requirements of this, as of other coccolithophorids, may prove to be of help in understanding their distribution.

Coccolithus Huxleyi belongs to the group of "oceanic" species which reach their highest numbers in inshore waters (Lohmann 1920, Birkenes and Braarud 1952). The explanation of this paradoxical fact may also be found when its physiology is studied experimentally. (For a discussion of the types of distribution and the terms neritic and oceanic, see page 28).

c) Dinoflagellates.

Exuviaella baltica Lohm.

Fig. 12.

This is one of the most widely distributed phytoplankton species of northern waters. It occurs in the North Atlantic proper (Gran 1912, Steemann Nielsen 1935, Grøntved 1953, Holmes unpubl.) and also on the western side of the Atlantic (Gran and Braarud 1935), in the Norwegian Sea (Gran 1915, Braarud 1935, Steemann Nielsen 1935, Halldal 1952) and along the Norwegian coast as far north as the Tromsø region (Ringdal Gaarder 1938). Wulff (1916) records it from the White Sea. In the North Sea Gran (1915) reports it as common.

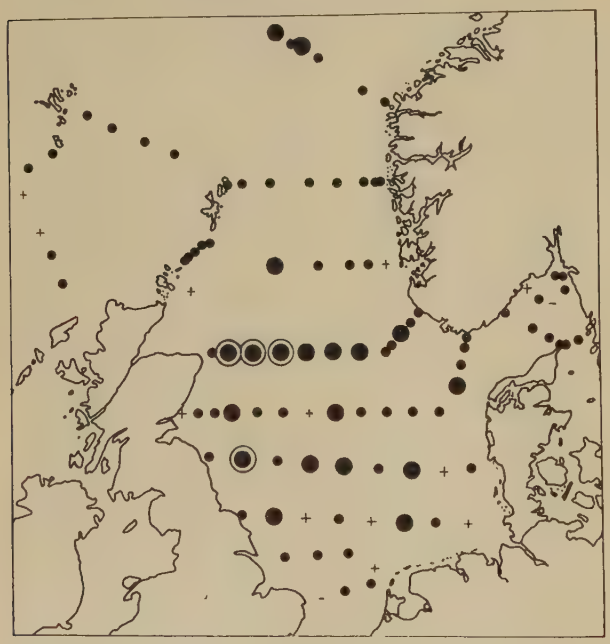

Figure 12. *Exuviaella baltica*. Distribution in May 1948. Maximum numbers at each station (cells per litre).
+ 0— 1,000 ● 10,001—100,000
• 1,001—10,000 ◉ 100,001—

In May 1948, it was recorded in varying numbers at all stations except two. It was observed in all types of water, but the largest populations were recorded in Atlantic waters on their way southwards along the western side of the North Sea (cf. Fig. 12 and Plate A).

Its quantitative distribution does not give any clear hint as to the main factors determining its relative abundance. In contrast to *Coccolithus Huxleyi* there always seems to be a population sufficiently large to form the basis for a more abundant population if conditions of growth become suitable. One might tentatively suggest that the waters in which *Exuviaella baltica* is present in abundance are those in which competition with diatoms is not too important, and where a fairly good supply of nutrients is present.

The biogeographical data as a whole indicate that *E. baltica* does not favour special temperature or salinity conditions. So far only the salinity effect has been studied experimentally. Braarud (1951) found that among the species investigated no other showed such a wide range of salinity wherein the rate of growth varied only slightly. It had a rather vague optimum at the low salinity of 10‰, the lowest for all species studied, and still showed a good growth at salinities higher than those met with in this area.

This explains why, even in an area with such pronounced differences in hydrographical conditions as ours, the distribution of *E. baltica* is so wide and general without any striking features. The population seems to be partly autochthonous, partly allochthonous, a portion having been brought in with the Atlantic water masses in which it also is a characteristic member of the plankton.

Figure 13. *Ceratium* — all. Distribution in May 1948. Maximum numbers at each station (cells per litre).
+ 0—100 ● 501—1,000
• 101—500 ◉ 1,001—

Ceratium spp.

Fig. 13.

The most numerous *Ceratium* species were *furca*, *fusus* and *tripos*. They were in general more numerous in the eastern and southern parts than in the western and northern, a fact which is due to the general distribution of the various types of phytoplankton communities. The dinoflagellate plankton of the central area of the North Sea also had its most regular Ceratia component in the eastern half, although fluctuations from one station to another were apparent (cf. Fig. 13).

In the Atlantic water masses on their way into the North Sea, and in the local communities around the Færoes, the Shetlands and the Orkneys, Ceratia were recorded either in small numbers or not at all.

perature upon growth is also being studied by NORDLI (1953). Preliminary results indicate that the temperature optimum for *C. fusus* lies at 15° C.

These experimental results support the classification of these *Ceratium* species as neritic members of an oceanic genus.

D. The Composition of the Phytoplankton.

a) Biogeographical types.

In the North Sea and adjacent parts of the Norwegian Sea, including the coastal areas, the phytoplankton communities are most heterogeneous as to the biogeographical nature of their components.

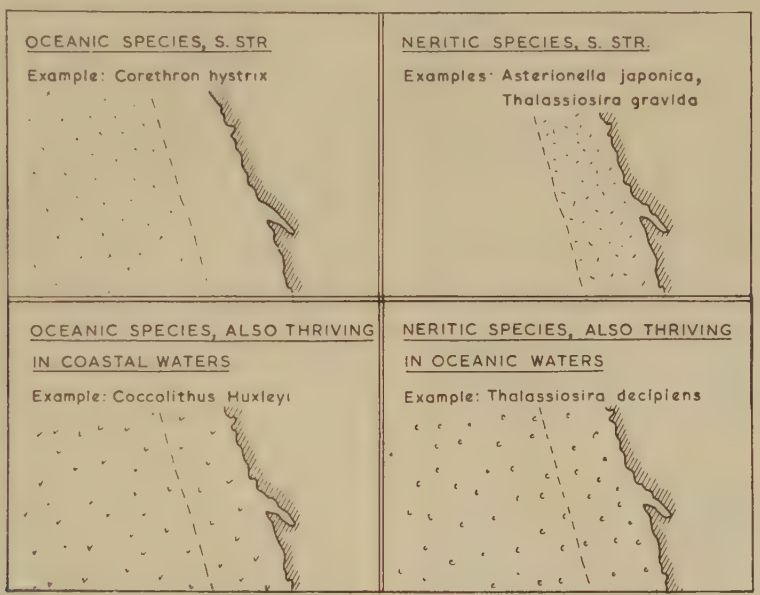

Figure 14. Distribution in coastal and offshore waters of neritic and oceanic species. (Cf. Figs. 7, 11 and 15).

Since GRAN's survey some information has been obtained on the physiology of these Ceratia, and this gives some of the background for their distribution.

RYTTER HASLE (1951) was able to demonstrate how the Ceratia in inner Oslo fjord undertook diurnal vertical migration of phototactic nature. This confirms, as far as light is concerned, GRAN's suggestion (GRAN 1912, 1915) that they may be able to seek the most favourable depth. Whether other ecological factors, such as nutrient supply, affect their phototactic reaction has not been investigated.

The effect of salinity upon rate of growth has been studied by NORDLI (1953) for the following species:— *C. furca*, *fusus*, *lineatum* and *tripos*. In so far as one can rely upon clone experiments (cf. BRAARUD 1951), NORDLI's results indicate that the salinity optimum for *C. fusus*, *furca* and *tripos* is around 20—25 ‰. At lower and higher salinities growth is somewhat poorer, but the decrease is slow. The effect of tem-

Since GRAN (1902) described the "plankton regions" of northern waters and analysed the various "plankton elements" which occurred, little new has been contributed in the way of analyzing the composition of the marine phytoplankton communities from an ecological point of view.

GRAN accepted HAECKEL's (1890) terms "neritic" and "oceanic" and modified CLEVE's (1900 c) regional system by introducing the terms "Arctic", "Boreal" and "Temperate-Atlantic", the last one subdivided into two groups, α) species which propagate regularly in the area, and β) occasional visitors.

The ecological system of GRAN has been used extensively and, in the course of time the lists of species for each group have been modified, as GRAN foresaw that they would be.

Today our detailed knowledge of the occurrence of the various species is more extensive and their ecological classification on a biogeographical basis is becoming

Figure 15. Stations where *Corethron hystrix* was recorded in May 1948.

increasingly difficult. New subdivisions would seem desirable, but any system based on biogeographical data is today, at the present state of biological research, felt to be unsatisfactory.

When describing the phytoplankton distribution, we have used the terms neritic and oceanic in a general sense, since they can hardly be maintained in the strict sense of Haeckel (1890) and Gran (1902). Examining the details of distribution one gains a strong impression that each of these groups contains a variety of ecological types which, in their distribution, exhibit remarkably different relationships to the coast. In order to illustrate this fact we may refer to examples from our region given in the diagram, Figure 14.

In addition to these examples one might also add indifferent species like *Exuviaella baltica*, a type which Gran (1902) also commented upon (cf. Fig. 12).

We do not propose to establish new biogeographical types corresponding to these examples. Each of the groups is heterogeneous and a more satisfactory ecological classification has to await further progress in the experimental studies of phytoplankton.

b) The biogeographical nature of the phytoplankton of the different areas.

The distribution of phytoplankton communities in May 1948 has been discussed in chapter II, page 11.

Apart from the Atlantic current proper entering the Færoe-Shetland Channel, the waters of the region are of a strikingly heterogeneous nature. This also applies to their phytoplankton populations. One of the features clearly demonstrated through an analysis of the vegetation in May 1948, is the importance of initial populations to the phytoplankton community of a water mass.

Since mixing processes obtain extensively in the area, allochthonous supplies to the local phytoplankton play an important part, in coastal as well as in offshore communities. Below is found a diagram of the combinations observed.

Striking examples of the importance of an allochthonous component of oceanic species in neritic phytoplankton communities have been recorded from Norwegian fjords (Gran 1929, Ringdal Gaarder 1938, Braarud and Hope 1952, Birkenes and Braarud 1952). The influence of coastal neritic populations upon inshore communities in tidal areas and fjords has been demonstrated for Danish waters (Grøntved 1949, Steemann Nielsen 1951).

Similar processes, but on a larger scale, take place in our area. We have seen how, for *Coccolithus Huxleyi*, its distribution at this time of the year is determined mainly by the spreading of initial populations by the recently introduced Atlantic water masses. The same applies to other coccolithophorids as well.

On the other hand, offshore neritic communities, as found in the northern North Sea, would seem to be the result of contributions of initial populations from waters of neritic character (cf. p. 16).

The local neritic vegetations originate in populations surviving in the area, either as cysts on the bottom or in a pelagic or semipelagic state. Currents may also lead to admixture of allochthonous neritic forms, a feature which may cause considerable fluctuation from year to year since currents vary in strength, direction and plankton content.

	Autochthonous supply of phytoplankton	Allochthonous supply of phytoplankton
In coastal waters:	Neritic species.	Oceanic or indifferent species, brought in by admixture of waters from offshore.
	Local populations of indifferent species.	Neritic species, introduced by admixture of coastal waters from other areas.
In offshore waters:	Oceanic or indifferent species, permanently present, but in varying numbers.	Neritic or indifferent species, being brought out to sea by coastal waters, which are mixed into oceanic waters.

III. Comparison with Results obtained during Previous Surveys.

A. The International Survey in 1912 (Gran 1915).

A comparison with the results obtained during the 1912-survey in the same region (Gran 1915) is of special interest. Material was collected at the same season, two weeks later than in 1948, and covers much the same area. In Figure 16 the location of the stations where phytoplankton samples were collected in 1912 is shown. The samples were worked up according to the centrifuge method, Fleming's solution (Gran 1912) being used as a preservative. When comparing the results, it must be kept in mind that this preservative destroys the coccolithophorids, the coccoliths being dissolved by the acids which it contains.

In order to facilitate a comparison between the phytoplankton societies recorded during the two surveys we have prepared a distribution chart for the 1912-survey similar to that shown in Plate A for the 1948-material. (See Plate B where the numbers used for vegetation areas correspond to those used for 1948.) The 1912-material is too small for a comparison of all the water masses which have been treated separately above, but for certain of them the sections give sufficient evidence to warrant comparison in some detail. We may first deal with the features which are common to the 1912 and 1948 situations and afterwards discuss the points of difference.

a) The central and southern North Sea.

The section crossing the central part, worked on 4—9. June, goes through the "central area" of the 1948-survey. The phytoplankton population was of a nature similar to that observed in 1948, with high figures for the Ceratia on the eastern side. It was generally a very poor plankton and as far as the difference in method allows us, we may conclude that it was essentially of the same nature. *Exuviaella baltica* was, however, recorded in much smaller numbers in 1912.

The stations to the south of this section were also poor, but with minor differences in the composition of the population, which is in accordance with what was observed in 1948. The occurrence of rather large populations of the tychopelagic form *Melosira* (*Paralia*) *sulcata* at the stations off the mouth of the Channel was also observed in 1948. At station 4 C alone there occurred a *Chaetoceros debilis* population which may well represent the coastal waters of this area. It would seem natural that by this time of the year the succession in the coastal diatom populations should have reached the *Chaetoceros* stage. At some of the southernmost stations a few diatoms were also recorded, mainly *Thalassiosira gravida*, which may indicate that a coastal diatom population similar to that observed in 1948 had occurred. There is, however, one remarkable difference; *Asterionella japonica* was absent here, as in the rest of the 1912-material.

b) The Skagerak and the Norwegian coastal current.

In the Skagerak and the stations off the Norwegian coast a poor "summer plankton" was encountered, similar to that in 1948. Ceratia were somewhat more abundant, and at stations 38 C, D and E (G XVI b) a population of *Leptocylindrus danicus* was recorded to which there was no counterpart in 1948. The northernmost stations represent an area which in 1948 had a plankton different from that of the current farther south. This was not the case in 1912, but the lack of data for the coccolithophorids hinders a closer examination of this problem. The differences in the two parts of the coastal current indicate that the hydrographical conditions within this area were essentially different in the two years. One can suggest that the Stavanger-eddy may have occurred in the position indicated on Tait's chart in 1912 but not in 1948. Farther north, conditions in the coastal current in 1912 seem to conform with the situation indicated in the chart, while in 1948 there was a compression of the coastal current, probably due to excessive pressure from the Atlantic waters, accompanied by extra turbulent activity in the local coastal waters.

c) The Færoe-Shetland Channel.

For this area the coccolithophorid vegetation was especially significant in the 1948-material, consequently a comparison with 1912 is difficult, but certain features stand out and seem to show that the situation was similar, although not exactly the same, in the two years.

The inflow of Atlantic water over a broad front in the southern section was obvious also in 1912 and this water was recorded in the northern section only at station 13 A on the Shetland side. The water masses to the west of this station had a rich *Nitzschia delicatissima* population, a sign of a connection with waters farther north. The next stations to the west, 15 A and B, 16 A, had a poor diatom vegetation, which indicated admixture of some water from the Færoe region, as was also observed in 1948. At the stations closest to the Færoes a rich diatom population was also recorded in 1912, but the composition of the plankton was of a more advanced type than in 1948. Since the 1912-section was worked in the last week of May, a fortnight later than in 1948, it is only reasonable that the diatom vegetation should have reached the *Chaetoceros* stage, the *Thalassiosira* vegetation having been succeeded by other diatom species. The stations near the Orkneys had a *Chaetoceros*

Figure 16. Phytoplankton stations during the international survey in 1912. (Cf. GRAN 1915).

population, different at the two stations 21 A and 21, with *Ch. teres* as the predominant species at the former and *Ch. debilis* and *decipiens* at the latter.

On the whole one may conclude that the situation within the Færoe-Shetland region was essentially the same in the two years, with differences of such a nature as might be expected from the difference in season.

d) The Shetland area.

Here the different location of the stations in the two years makes a comparison somewhat difficult, but some essential deviations seem evident.

In 1912 station 12 to the north of the Shetlands had a *Nitzschia delicatissima* plankton similar to that encountered at the stations farther north (cf. Plate B). This society was definitely different from that recorded on the south-eastern side of the islands where there was a very poor diatom vegetation wherein *Nitzschia delicatissima* was of no importance (G IV). The plankton was here of a character similar to that observed between the Shetlands and the Orkneys and encountered also at stations farther to the east, 38 I and 38 H. The nature of this society makes it natural to compare it with the diatom populations observed at the Shetlands in 1948 and to regard it as representing a later stage in the succession.

In the 1948-material the area to the south-east of the Shetlands (V) had a diatom population which was retarded in its seasonal succession as compared with that of the Shetland region. The 1912 picture shows waters of a similar character, now situated a little farther south, at stations 30, 32 (28). Here *Thalassiosira gravida* and even *Nordenskioeldi* still dominated the population. This is an interesting record which would indicate that the state of affairs described for 1948 may be a regular feature of the area outside the Moray Firth.

e) The northern North Sea.

In 1948 the region to the north of the central area showed a rather complicated phytoplankton picture (cf. sections H and F in Plate A). The 1912-material contains two sections crossing this region. The data from the southern section show an interesting agreement with conditions in 1948, with a central diatom population between the poor coastal current to the east and another poor area to the west. The exact location is not easily compared, the stations lying too far apart. The composition of the diatom vegetation is somewhat different, but suggests a similar stage in the succession. (At 38 B a *Thalassiosira gravida* population occurred, which may be a relatively earlier stage than the rest).

The more northern of the two sections indicates that the Norwegian coastal current extended much farther to the west than in 1948, the stations 38 G and F having poor populations of a character similar to those off the Norwegian coast. Records on the coccolithophorids might, however, have changed the picture, and we are therefore not going into further detail on the situation in this region; it is such a complicated hydrographical area that it would seem of little interest without having comparable observations on the coccolithophorids also.

f) The Norwegian Sea.

The vegetation charts in Plates A and B indicate that conditions may have been rather different in 1912 and 1948, but the general nature of the populations was the same. The area is characterized by a vegetation where neritic and oceanic components are mixed and the populations are large. As mentioned before, we prefer to postpone the discussion of details in phytoplankton growth here until more extensive material from other parts of the Norwegian Sea is available.

The general impression of our comparison between the surveys in 1912 and 1948 is that the main features in the vegetation were much the same. The extents of the vegetation areas in 1912 were not exactly identical with those in 1948, but on the whole they seem to represent parts of the same pattern (cf. also p. 34).

B. Observations in 1947 (Grøntved 1952).

Figure 17 shows the area where plankton investigations were carried out in 1947; it will be seen that the samples were collected in sections practically the same as our sections Q, R, and S in 1948. In 1947 the sections R and S were worked on 5—8. May, the same time of the year as in 1948. A fortnight later—19—22. May—the collection was repeated in section R and the more northern section Q was worked. The plankton samples were preserved in neutralized formalin and examined with the inverted microscope according to the sedimentation method—as was our 1948-material.

For the relatively small area covered by the investigations in both years there are good possibilities of making a comparison. The two sets of observations in 1947 in the northern part of the area are of special value in this respect. In comparing the pelagic vegetations we mention only certain main features, omitting details of local significance only.

In the western coastal waters we have in both years a preponderant diatom flora consisting of *Asterionella japonica*, *Chaetoceros* spp., *Melosira sulcata* and *Sceletonema costatum* as the most important components. The vegetation at the stations Q_{24} and S_1 was very rich in both years, whereas R_1 was a rather poor plankton station.

In the first sampling period in May 1947 the south-flowing Atlantic current was characterized by rather large quantities of the same diatom species as those occurring in the neighbouring coastal waters. In the

latter half of May 1947 and in the sampling period of 1948 this diatom stock was strongly reduced while components of dinoflagellates and other flagellates were taking the lead.

In the Dogger area we had in the beginning of May 1947 a diatom flora rich in *Chaetoceros* spp., *Thalassiosira* spp., *Leptocylindrus minimus* and *Nitzschia delicatissima*; in the latter half of this month the numbers of diatoms were strongly diminished and flagellates had become more prominent. In 1948 *Rhizosolenia imbricata* var. *Shrubsolei* had a considerable density in this area, as also had dinoflagellates, with *Exuviaella baltica* as the leading species, and other flagellates.

In both years the eastern coastal waters were characterized by having diatoms as a significant element in their vegetation, especially *Chaetoceros* spp. and in 1948 also *Asterionella japonica*.

In the southern coastal area (comprising the stations of section S between the eastern coastal waters and Dogger Bank) the plankton of the station 6528 had a special character in accordance with the hydrographic conditions prevailing there in 1947; for the rest, the tychopelagic diatom *Melosira sulcata*, *Thalassionema nitzschioides* and *Nitzschia delicatissima* were rather frequent. In 1948, when on the whole diatoms were more scarce, this southern influence was less pronounced; it may be mentioned that *Coccolithus Huxleyi* was present here only in small numbers.

In the central area the vegetation was rather poor in both years, flagellates being a characteristic element. In 1948 *Exuviaella baltica* was the most numerous species and *Coccolithus Huxleyi* was present, though in small numbers; in 1947 the former had only scattered occurrences and the latter was not recorded.

It appears from the foregoing that on the whole the pelagic vegetations of our area in the two years had marked similarities. Only the occurrences of *Exuviaella baltica* showed a marked difference. In 1948 this species was distributed all over the area, and in several places it occurred in great density; in 1947 it appeared only in scattered places and always in small numbers.

When comparing the collections from the beginning of May in the two years, and omitting the coastal waters, a major difference is a predominance of diatoms in 1947; this year the plankton succession at the beginning of May had not reached further than the *Chaetoceros* stage. The populations at the beginning of May in 1948 and in the latter half of the same month in 1947 show great similarity from the viewpoint of succession; in both the diatom vegetation was on the decrease and the flagellate population on the increase.

With regard to the reason for the retarded stage of the succession in 1947 as compared with that in 1948, we may point out that the hydrographic conditions were also different in the two years. The temperature was extraordinarily low in the spring of 1947 and the water masses were homogeneous when plankton was collected on 5—8. May; a fortnight later a state of stabilization had been reached (Grøntved 1952). In early May 1948 the temperature values in the upper layers were somewhat similar to those in the middle of May 1947. Probably the difference in the plankton succession in early May in the two years is due mainly to an earlier development of the populations of grazers following on the earlier rise in temperature in 1948.

C. Plankton Recorder Results.

The plankton recorder constructed by Hardy (1935) has been used for extensive investigation on the phytoplankton in the North Sea and also in the Færoe-Shetland region. During 1932—37 investigations were confined to the southern North Sea (Lucas

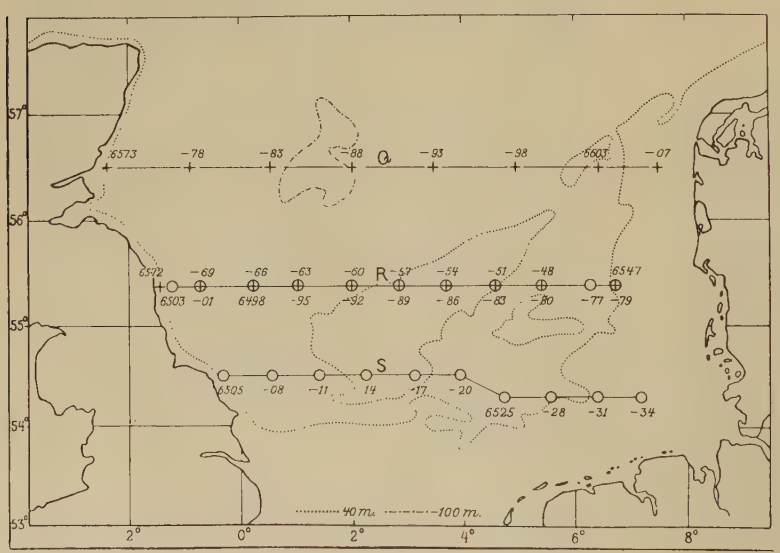

Figure 17. Map showing the plankton stations in the southern North Sea in May 1947. The sections R and S were worked on 5—8. May; those stations are marked ○. At the stations marked + in sections R and Q plankton was collected on 19—22. May. The symbol ⊕ in section R indicates localities where plankton sampling was carried out in both the periods mentioned. (From Grøntved, 1952).

and Rae 1946, Lucas 1940), while in 1938—39 the whole North Sea was studied (Hardy 1941, Lucas 1941, 1942) and in 1939 the Færoe-Shetland Channel (Lucas, Marshall and Rees 1942).

The apparatus used in these investigations filters the sea water through silk No. 6, which has meshes permitting a great number of the common diatoms, smaller dinoflagellates and all coccolithophorids to pass through. On account of clogging, the efficiency of filtering is apt to vary considerably according to the phytoplankton community which is being filtered, and the different species may be recorded in different proportions. In spite of the disadvantages of the method (such as the loss of the nanoplankton which will also occur in any net method) the investigations have produced interesting data on the seasonal occurrence of larger diatoms, mainly *Rhizosolenia styliformis* and *Biddulphia sinensis*, which in the southern North Sea are of special interest. Also their occurrence over a period of several years has been recorded.

The observations from the Færoe-Shetland area in May, 1939 show high figures for "*Thalassiosira* spp." in the channel, while it was not recorded close to land on the Scottish side. In our A-section which is from the same area, *Thalassiosira decipiens* was the only species of this genus occurring regularly. It was recorded in very small numbers.

Observations on the changed position of the *Rhizosolenia styliformis* and *Biddulphia sinensis* patches were used for drawing conclusions as to the water movements within the southern part of the North Sea. These mainly refer to the autumn and are, therefore, of little interest for comparison with the present material.

D. Previous Investigations relating to the Influx of Atlantic Water through the English Channel.

The lack of coccolithophorids, especially *Coccolithus Huxleyi*, in the southern North Sea, even at the entrance to the English Channel (cf. Fig. 11), suggests that in May 1948 no recent contribution of water containing coccolithophorids, similar to the influx in the north, had taken place in the south. This remarkable feature in the coccolithophorid distribution raises the question of the nature of the waters carried into the North Sea through the Channel. A review of previous investigations relating to this problem may be useful.

Gough (1905, 1907), from his extensive studies on the phyto- and zooplankton distribution in the Channel, based upon net-haul samples, was able to draw important conclusions on water transport through the Channel. He writes (p. 327): "It seems unlikely, therefore, that during 1903 there was a current rapid enough to carry its plankton unmixed far up the Channel. If there was a current it must have been a very slow one, sufficiently slow to allow the neritic fauna and flora to develop and supercede the original oceanic inhabitants".

Russell (1938) has summarized the general principle of the circulation in the English Channel region in this way: "Through oceanic circulation and wind effects there is a resultant flow of water through the straits of Dover into the southern North Sea. The supply from which this water is ultimately drawn enters the western mouth of the Channel either from the west or the south-west. It is generally conceded that more water enters the Channel than can pass through the Dover straits and this surplus probably drifts north-west or north past the Scillies—Land's End region, though the actual state of affairs here is still not clear. To the west of the mouth of the Channel is an anticyclonic swirl lying over the shallow continental plateau south of Ireland. This swirl varies in its extent and position; at times it appears to block the mouth of the Channel and at others it apparently retreats farther north, thus laying the Channel mouth open to more oceanic water from the south and south-west. When there is a strong flow through the Dover straits, water may move up Channel past Plymouth either from the swirl or from the ocean according to the conditions existing off the Channel mouth. In the Channel itself there must be a body of water constantly being added to from the west and dissipated to the east, or hemmed into the coast to allow for passage of more oceanic water. The circulation of water in the Channel itself is clearly very variable from time to time."

The Channel water is characterized by its poverty of plankton and by its indicator species *Sagitta setosa*, while the water in the swirl and the oceanic waters each have characteristic zooplankton.

Lebour (1917) studied centrifuge samples from every week throughout a year (1915—16) and found that in the Channel off Plymouth diatoms were numerous from April till October with a spring maximum (April—May) and an autumn maximum (August—September). The most important species of the spring maximum was *Sceletonema costatum*. Other diatoms of the spring-summer group included the genera *Asterionella, Chaetoceros, Lauderia, Nitzschia, Rhizosolenia, Thalassiosira*. Those of the autumn group included *Biddulphia, Coscinodiscus, Melosira* (*Paralia*), *Streptotheca* and *Thalassionema* (*Thalassiothrix*). — *Sceletonema* occurred practically all the year round with maxima in April and September. Other species having two maxima were *Chaetoceros curvisetus* (May and September), *Lauderia borealis* (April and August) and *Thalassiosira gravida* (May and September). Lebour found that her results were in general agreement with the previous records from net-haul samples in the same area (Gough 1905, 1907, Bygrave 1911).

Of coccolithophorids only *Coccolithus Huxleyi* was observed. It occurred occasionally in summer, and in early autumn it was sometimes abundant. (The water samples were examined fresh if possible. Otherwise Fleming's solution, according to Gran (1912), was used.)

In a subsequent report LEBOUR (1923) discusses the occurrence of coccolithophorids in the Channel. She found (p. 274) that "*Pontosphaera Huxleyi* LOHMANN, the only other coccosphere so far known in this district, is found less frequently, but may easily be passed over owing to its small size . . . The present records show it to occur in August, February, and May from comparatively near the shore and from E 1, from the surface to the bottom (70 metres) . . . It is thus seen that these two species (*Coccolithus pelagicus* and *Coccolithus Huxleyi*[1]) are common in the district, and so far no others have been observed. From the notes given above they must be important members of the phytoplankton, and, at any rate in the case of *Coccolithophora* (*Coccolithus pelagicus*), are noteworthy as nourishment for the plankton-eating animals."

GRAHAM and HARDING (1938) have made observations on the hydrology and phosphate distribution in the Channel and the southern North Sea. The salt and warm waters in the western part of the Channel were found to be separated from the North Sea water by bodies of water of a definitely different character during all the three years of observation.

From our findings, one may deduce that the Channel water at the time preceding the observations was poor in coccolithophorids. The oceanic water masses to the west of the Channel may, on the other hand, be expected to have had a population similar to that which was recorded in the Færoe-Shetland Channel. According to this assumption the exchange of water through the Channel does not seem to have taken place very quickly at the time preceding our observations, which is in full agreement with RUSSELL's and GRAHAM and HARDING's descriptions of the general situation.

Conditions in the Channel in many ways seem to be similar to those described in the passages from the Bay of Fundy into the Passamaquoddy Bay (GRAN and BRAARUD 1935).

E. Other Surveys.

In addition to the surveys mentioned above two quantitative phytoplankton surveys may be mentioned.

WULFF (1925) studied the phytoplankton by means of the centrifuge method on material from cruises in January, March and April 1920. The first cruise was off the coast of the Netherlands, the second was off the German coast and the April cruise included sections in the central-eastern and the north-eastern parts of the North Sea. One of the remarkable features was the occurrence of the Atlantic coccolithophorid *Discosphaera tubifer* at all stations in the central and the north-eastern sections. This species was not recorded in 1948. *Coccolithus Huxleyi* was recorded in small numbers in the southern part of the central area, where other coccolithophorids were also present in similar small numbers.

Although no detailed comparison can be made, since these samples were collected earlier in the season, it may safely be concluded that the Atlantic component of the vegetation had a composition different from that observed in 1948.

VAN GOOR (1923) studied surface and bottom samples collected in a section across the southern North Sea in March and April 1914, using the centrifuge method according to GRAN (1912). Coccolithophorids are not recorded by this method. The vegetation consisted of dinoflagellates and ciliates and a large number of bottom diatoms, even at the surface. It had a character similar to that recorded in the present survey.

Observations on net plankton have been carried out by various methods. British investigations of phytoplankton in connection with herring investigations (SAVAGE and HARDY 1935, HENDERSON, LUCAS and FRASER 1936, SAVAGE and WIMPENNY 1936, CHENG 1941) have yielded interesting information on the occurrence of patches of *Phaeocystis* and of larger diatoms which can be caught in nets. Earlier observations on net plankton have been treated by GRAN (1915). We are only going to refer to CLEVE's investigations (CLEVE 1897), since they cover the main part of our region.

In Figure 18 a chart is reproduced from CLEVE's paper. The areas which he distinguished may be compared with those in our vegetation chart, in spite of the fact that CLEVE's chart refers to the month of January 1897.

The Concinnus-plankton, closest to the coasts, to a certain extent corresponds to our coastal diatom area. Then comes a *Halosphaera*-zone which, at least in the western part, would correspond to our south-flowing waters of Atlantic origin. Since *Halosphaera* is an oceanic species with abundant occurrence in the Atlantic, this feature also seems to be in agreement with the 1948-observations. The central North Sea is characterized by Triposplankton, in good accordance with our "poor dinoflagellate" vegetation in the same area. In the Skagerak a Trichoplankton and a Sira-plankton area are marked, different from those of the other areas.

It is interesting to see how the broad features of the main vegetation areas, which we have distinguished on the basis of our quantitative material, appear also in CLEVE's chart. Finer details are, of course, missing. The agreement may be taken as a sign that these features are essentially the same now as they were at the time of CLEVE's investigation.

F. Variations from Year to Year.

The material from previous investigations does not allow any definite conclusions to be drawn as to the extent of variations from one year to another in the

[1]) The insertion made by us.

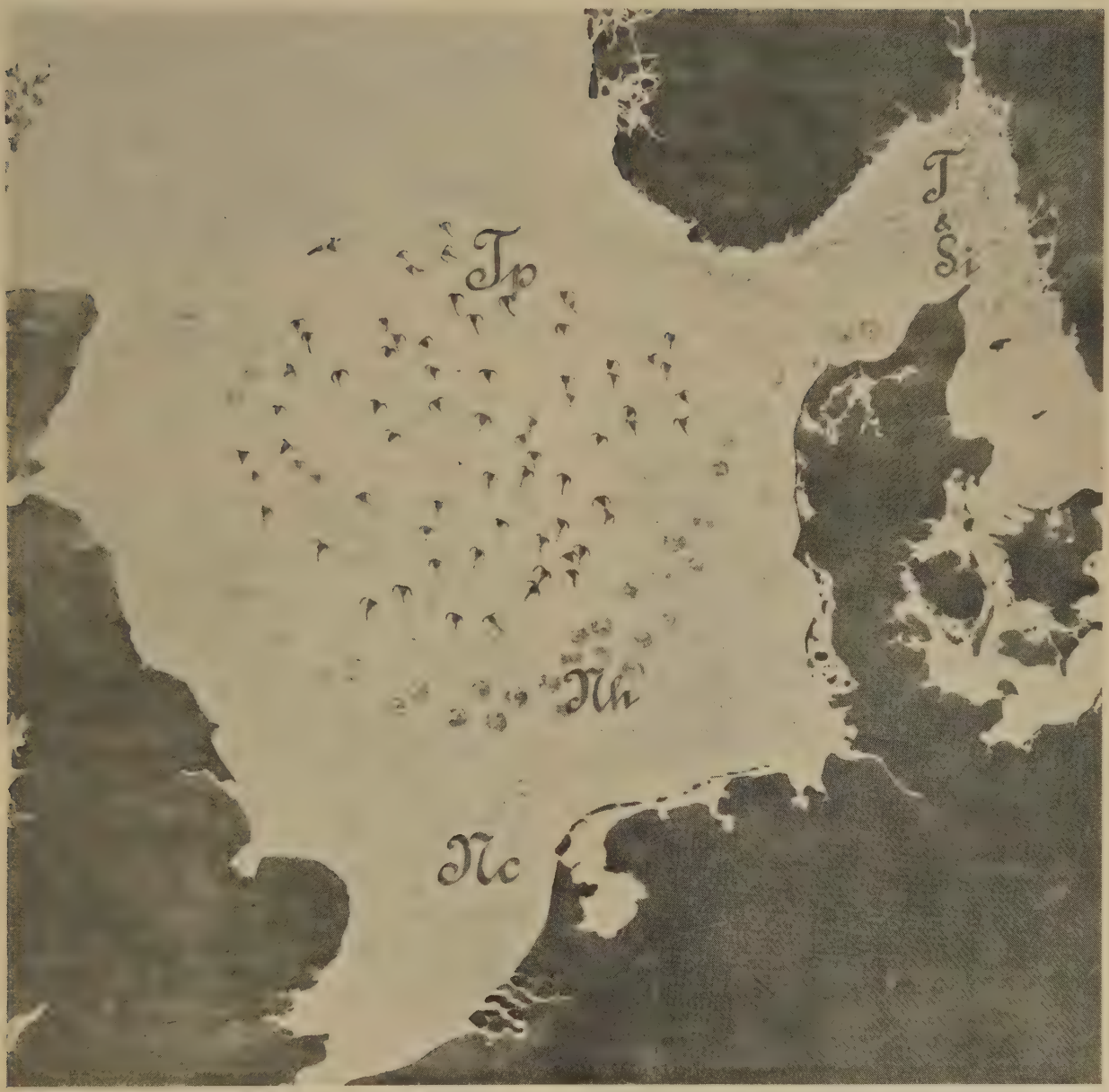

Figure 18. Phytoplankton societies in the North Sea, January 1897, according to observations on net-haul material. (After Cleve, 1897).

Tp, Triposplankton; T, Trichoplankton; Si, Siraplankton; Nh, Halosphæraplankton; Nc, Concinnusplankton.

vegetation of the North Sea. There are, however, certain indications.

The extensive observations by Cleve (1897) and Gran (1915) support the assumption that the general features in the picture obtained in May 1948 represent the essentials in the distribution in our area of water masses with different phytoplankton communities. On the other hand, Gran's observations from the northern North Sea and Wulff's (1925) observations from the north-eastern North Sea indicate that the hydrographical conditions may differ considerably in detail, even at the same season of the year, and the vegetation areas change accordingly. Gran's observations showed a far more westerly extension of Norwegian coastal waters in 1912 than in 1948 in the area west of Stavanger, and Wulff's data indicate a more pronounced Atlantic character of the waters off Lindesnes than in our survey.

The most striking deviation from the 1948 conditions were, however, recorded in 1947 (Grøntved 1952), when hydrographic conditions in the North Sea were most extraordinary (cf. the hydrographic report from the international survey for this year). The seasonal change from a diatom to a dinoflagellate plankton in the central area was greatly delayed and the thermal stratification of these waters was not effected until late in May.

The interesting observation that in 1948 the Atlantic component of the vegetation of the central area was strikingly different from that recorded in 1920 by Wulff (1925) gives a hint that considerable changes may take place in the supply of allochthonous populations to the North Sea.

The changes in the *Rhizosolenia* and *Biddulphia* patches in the southern North Sea (cf. above) remind us again that in this area of complex hydrographic contributions and influences, fluctuations of considerable magnitude are to be expected. A more regular recording of these fluctuations would certainly serve the interests of many biological fields.

IV. Concluding Remarks on the Phytoplankton Conditions in the Region.

A. Ecological Remarks on Conditions in May 1948.

When trying to trace the ecological background for the phytoplankton distribution which was recorded during the survey, we may consider the problem in two main parts, a) the causes of differences in size of the population from one water mass to another; b) the causes of differences in composition of the phytoplankton in the various water masses.

In spite of the fact that no satisfactory analysis of the ecological interaction of all the factors involved is feasible, we may comment briefly on the two problems with our present material in view.

a) Differences in size of the population.

In the previous chapters stress has been laid upon the hydrographic conditions of the water masses as the main decisive factor responsible for the striking differences in the plankton from one locality to the other. This factor influences a number of primary ecological factors of phytoplankton growth such as nutrient supply, light conditions (turbidity), and supply of initial stock. Surveying the area as a whole we therefore find that the hydrographical factor also seems to be responsible for the large differences in the quantitative distribution of phytoplankton. In various places different hydrographic effects are predominant in the ecological picture (*vide* the review given in Chapter II B).

Two problems of a more general nature may be mentioned here.

i) It has been suggested repeatedly that oceanic water offers less favourable conditions for plankton growth than coastal waters (Gran 1931), and it has also been shown that growth factors of organic nature (Harvey 1939), auxines and other hormones (Steemann Nielsen 1940, 1944, Levring 1945) and soil extract (Braarud 1937) stimulate growth of certain groups of phytoplankton organisms in cultures. The question may be raised whether the present extensive survey seems to indicate similar effects in nature. The answer must be that the offshore and coastal waters in May 1948 do not reveal differences in the phytoplankton which may not reasonably be attributed to variations in the following ecological factors: 1) supply of an initial stock of suitable organisms, 2) dilution of the population of the euphotic layer by vertical transport, 3) supply of nutrients from deep waters and 4) turbidity.

ii) The "effect of land" which has been mentioned as a possible cause of differences between coastal and offshore waters as regards phytoplankton density is obviously such a complex factor that only experimental studies are likely to yield reliable information as to the separate effects of the various components involved. As long as quantitative estimates of turbulence, as well as detailed information on submarine light and the supply of nitrogen and phosphorus compounds are lacking, an estimate of the exact effect of these factors is not possible. Consequently the question of the possible effect of other ecological agents must be left for future consideration. This is not to be interpreted as a negation of their possible importance.

b) Differences in the composition of the phytoplankton.

In the section on the distribution of selected species the importance of seeding of the waters was discussed. Another feature of eminent importance regarding the composition of the phytoplankton of a water mass is succession, which takes place in every phytoplankton community.

In the stratified waters in the Skagerak and the Norwegian coastal current succession has been most strikingly demonstrated. The general features are the same from one year to another, a series of spring diatom populations succeeding each other and dis-

appearing, while the dinoflagellate component stays on and increases during the summer. Succession also takes place within the dinoflagellate population, the relative abundance of various species changing with the season (Braarud 1945). In other waters of the area succession may take a different course.

The ecological background for succession seems to be manifold. In only a few cases can suggestions be made as to the active forces. Schreiber (1927) showed that the effect of temperature upon growth in *Biddulphia aurita* and *sinensis* seems to give an explanation of the seasonal occurrence of these species. In many other cases the classification of species in ecological groups according to biogeographical data (Gran 1902) suggests a similar temperature effect, but we have to await more experimental data before we can draw more definite conclusions (Braarud 1937).

The "conditioning of the water" (Lucas 1947) implies various effects of a population upon the water mass. Mutual influences of this nature most probably are at play in producing succession. If so, the factors which affect growth also influence the rate of succession.

We have, in a previous chapter, indicated that, for instance at H 16, the population represented a "retarded" spring diatom population. This expression was used with the implicit assumption of an ecological background for succession as given above.

Grazing is doubtless one of the most important processes which influence the seasonal abundance of phytoplankton. We may refer to the steep decline after the spring maximum of the phytoplankton population in stratified coastal waters and to the remarkable changes which Grøntved recorded within a fortnight in the southern North Sea in May 1947 (Grøntved 1952). Differences in grazing intensity also seem to be the cause of conspicuous seasonal changes in phytoplankton abundance in Norwegian fjords in summer and autumn (Braarud 1944).

In our region there were doubtless, at the season of our survey, important differences in grazing intensity from one area to another, but we are not in a position to analyze the effect of this ecological factor upon population density.

B. The Phytoplankton as an Indicator of Hydrographic Conditions.

a) Current-indicator species.

Since Gran (1902) discussed the use of plankton organisms for identification of oceanic and coastal water masses in the Norwegian Sea, zooplankton has been used extensively for similar purposes (for literature see Russell 1935, Fraser 1952). Phytoplankton has also served the same purpose (Gran and Braarud 1935). From the results of the present survey the distribution of *Coccolithus Huxleyi* is an example of a species which is characteristic of Atlantic water or mixing products with a recent Atlantic component. It may be suggested that for a closer study of the inflow of Atlantic waters in the north it might be very useful and instructive to include the nanoplankton in the combined hydrographic and planktonological investigations which already have proved to give such interesting results with zooplankton as biological indicators (Fraser 1952). Although the most valuable information may be expected from the coccolithophorid component of the nanoplankton, the whole community must, nevertheless, be considered.

Also, in many other cases, a combination of plankton studies and hydrographical work in detailed surveys seems promising for solving problems on water exchange and mutual influence of water masses.

b) Other hydrographic features.

During the analysis of the vegetation in May 1948 it was possible to distinguish a number of water masses with different plankton communities. In such a heterogeneous area one may in this way obtain information on biologically essential differences between bodies of water which are not so easily distinguished on the basis of hydrographical data alone.

The background for the differences in vegetation may be manifold. For the present material we have tried to show that the prehistory of the water mass and the turbulent activities are of outstanding importance. On the basis of the vertical distribution and the character of the vegetation (stage of succession) it may, in many cases, be possible to draw tentative conclusions as to the hydrographical state of the water, as was done for the central area of the North Sea; these may serve as a starting point for further hydrographical studies.

C. Problems of Production.

The present survey was not intended to include estimates of the production of organic matter. Our distribution chart of May 1948 clearly shows that such an investigation would have to consist of a number of estimates, since conditions of plant growth are so different in each of the vegetation areas that the annual plant production may be expected to vary considerably.

The amount of organic matter available to animal life may show less seasonal variation in the turbulent waters than in those having pronounced stratification during summer, regardless of the relative quantities in each.

In view of Thorson's studies of the ecology of bottom dwelling animals (Thorson 1936, 1950) an examination of relations between bottom fauna, the hydrographic areas distinguished by Dietrich (1950) and our phytoplankton areas (Plate A) would seem to be desirable.

V. Summary.

1) The survey is based upon water samples from 100 stations in the North Sea, the Færoe-Shetland Channel and the southern Norwegian Sea in May 1948. At each station samples from 0, 10, 20, (30), and 50 m. were examined by the sedimentation method.

2) A detailed comparison has been made between the vegetation recorded at each station and the hydrographic conditions as expressed by temperature, salinity and density distribution. Information on current conditions was mainly derived from Tait's chart (1937).

3) On the basis of the vegetation, sixteen areas were distinguished (see Plate A) and it was demonstrated how these, to a large extent, correlated with those indicated in Tait's current chart. The vegetation area in the central North Sea did not seem to agree well with the chart.

4) The differences in vegetation were analyzed and the following two factors were found to be of paramount ecological importance: (a) stability of the water masses and (b) supply of initial populations. The twofold effect of turbulence in favouring the supply of nutrients from deeper strata and in diluting the phytoplankton population in the euphotic layer is discussed in relation to stability conditions.

5) In the inflowing Atlantic water masses an autochthonous population of the oceanic coccolithophorid *Coccolithus Huxleyi* and the indifferent dinoflagellate *Exuviaella baltica* was characteristic. In "older" Atlantic waters an admixture of allochthonous populations of neritic nature was noticeable.

6) The Atlantic waters around the Færoes, the Shetlands and the Orkneys had a very rich population in contrast to the poor vegetation of the main flow of Atlantic water into the North Sea.

7) The coastal areas of the North Sea proper had varied vegetations in which neritic diatoms were predominant. Here turbulence presumably assured a steady supply of nutrients. In the Norwegian coastal current a poor dinoflagellate vegetation similar to that in the Skagerak occurred. The main ecological background for this would seem to be the pronounced stratification which hindered the supply of nutrients from the deep layers to the euphotic zone after the spring diatom maximum.

8) The central North Sea had a poor vegetation. It is suggested that this central water mass was drifting slowly and, in spite of the small density gradients, had little turbulent activity.

9) On the Dogger Bank a characteristic *Rhizosolenia* vegetation flourished and small populations occurred in the north-easterly drift from this area. A moderate turbulent activity in the bank area ensures a good supply of nutrients.

10) Complicated phytoplankton conditions prevailed in the large eddy system in the northern North Sea. Influence from neritic vegetations to the west, from inflowing Atlantic water and from a more northerly branch of Atlantic water as well as from the north-eastern part of the North Sea was evident.

11) Extraordinary conditions seem to have prevailed in the Norwegian coastal current off Bergen, probably as an effect of pressure from a branch of Atlantic water pushing toward the south.

12) Two sets of observations in the southern part of the Norwegian Sea with an interval of two weeks between them showed a remarkable change in the phytoplankton, which was characterized by Atlantic coccolithophorids and neritic diatoms.

13) The distribution of selected species of diatoms, coccolithophorids and dinoflagellates is described and the biogeographical features of the phytoplankton communities are discussed.

14) A comparison is made with previous investigations, with special stress on the international survey in 1912. The main pattern seems to obtain, but differences in hydrographic conditions cause variations from one year to another in the seasonal cycle and in the extent of the vegetation areas.

15) The use of phytoplankton as an indicator of hydrographic conditions is discussed.

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VII. List of Species.

Diatoms.

Centric forms:

Actinoptychus senarius (Ehrenberg) Ehrenberg
Asteromphalus heptactis (Brébisson) Ralfs
Bacteriastrum elegans Pavillard
Bacteriosira fragilis Gran
Bellerochea malleus (Brightwell) van Heurck
Biddulphia aurita (Lyngbye) Brébisson & Godey
— *mobiliensis* Bailey
— *regia* (Schultze) Ostenfeld
— *rhombus* (Ehrenberg) W. Smith
— *sinensis* Greville
Cerataulina Bergoni Peragallo
Chaetoceros affinis Lauder
— — var. *Willei* (Gran) Hustedt
— *atlanticus* Cleve
— *borealis* Bailey
— — f. *concavicornis* (Mangin) Braarud
— — f. *typica* Braarud
— *cinctus* Gran
— *compressus* Lauder
— *concavicornis* see *borealis* f. *concavicornis*
— *constrictus* Gran
— *convolutus* Castracane
— ? *costatus* Pavillard
— *crinitus* Schütt
— *curvisetus* Cleve
— *danicus* Cleve
— *debilis* Cleve
— *decipiens* Cleve
— *densus* Cleve
— *diadema* (Ehrenberg) Gran
— *didymus* Ehrenberg
— *difficilis* Cleve
— *furcellatus* Bailey
— *gracilis* Schütt
— *laciniosus* Schütt
— *Lauderi* Ralfs
— *Pavillardi* Ikari
— *pelagicus* Cleve
— *peruvianus* Brightwell
— *radians* Schütt
— *radicans* Schütt
— *sessilis* Grøntved
— *similis* Cleve
— *socialis* Lauder
— *subsecundus*, see *diadema*
— *teres* Cleve
— *tortissimus* Gran
— *Wighami* Brightwell
Corethron hystrix Hensen
Coscinodiscus centralis Ehrenberg
— *concinnus* W. Smith
— *curvatulus* Grunow
— *decrescens* Grunow
— *excentricus* Ehrenberg
— *Grani* Gough
— *granulosus* Grunow
— *Kützingi* A. Schmidt
— — var. *glacialis* Grunow
— *lineatus* Ehrenberg
— *marginatus* Ehrenberg
— *oculus iridis* Ehrenberg
— *radiatus* Ehrenberg
— *Rothi* var. *subsalsa* (Juhlin-Dannfelt) Hustedt
Coscinosira Oestrupi Ostenfeld
— *polychorda* Gran
Dactyliosolen mediterraneus Peragallo
Ditylum Brightwelli (West) Grunow
Eucampia zoodiacus Ehrenberg
Guinardia flaccida (Castracane) Peragallo
Hemidiscus cuneiformis Wallich
— — var. *ventricosa* (Castracane) Hustedt
Hyalodiscus subtilis Bailey
Lauderia borealis Gran
Leptocylindrus danicus Cleve
— *minimus* Gran
Melosira dubia Kützing
— ? *italica* (Ehrenberg) Kützing
— *moniliformis* (Müller) Agardh
— *sulcata* (Ehrenberg) Kützing
Podosira stelliger (Bailey) Mann
Porosira glacialis (Grunow) Jörgensen
Rhizosolenia alata Brightwell
— — f. *gracillima* (Cleve) Grunow
— *delicatula* Cleve
— *fragilissima* Bergon
Rhizosolenia hebetata f. *semispina* (Hensen) Gran
— *imbricata* var. *Shrubsolei* (Cleve) Schröder
— *setigera* Brightwell
— *Stolterfothi* Peragallo
— *styliformis* Brightwell
— — var. *longispina* Hustedt
— — f. *bidens* (Karsten) Heiden & Kolbe
Roperia tessellata (Roper) Grunow
Sceletonema costatum (Greville) Cleve
Stephanopyxis turris (Greville & Arnott) Ralfs
Streptotheca thamesis Shrubsole
Thalassiosira bioculata var. *raripora* Gaarder
— *condensata* Cleve
— *constricta* Gaarder
— *decipiens* (Grunow) Jörgensen
— *gravida* Cleve
— *minima* Gaarder
— *Nordenskioeldi* Cleve
— *rotula* Meunier
Triceratium alternans Bailey

Pennate forms:

Achnanthes sp.
Asterionella japonica Cleve
— *kariana* Grunow
Bacillaria paradoxa see *Nitzschia*
Campylosira cymbelliformis (A. Schmidt) Grunow
Cocconeis scutellum Ehrenberg
Cymatosira belgica Grunow
Diploneis sp.
Fragilaria nana Steemann Nielsen
— *oceanica* Cleve
Grammatophora marina (Lyngbye) Kützing
Licmophora sp.
Navicula distans W. Smith
— *membranacea* Cleve
Nitzschia closterium (Ehrenberg) W. Smith
— *delicatissima* Cleve
— *paradoxa* (Gmelin) Grunow
— sp. *parva* Mielck
— *seriata* Cleve
Pleurosigma angulatum W. Smith
— *fasciola* (Ehrenberg) W. Smith

Raphoneis amphiceros Ehrenberg
— *surirella* (Ehrenberg) Grunow
Rhoicosphenia curvata (Kützing) Grunow
Striatella delicatula (Kützing) Grunow
Tabellaria fenestrata (Lyngbye) Kützing
Thalassionema nitzschioides Grunow
Thalassiothrix longissima Cleve & Grunow

Dinoflagellates.

Amphidinium crassum Lohmann
— *?Klebsi* Kofoid & Swezy
— *sphenoides* Wulff
Amphidoma caudata Halldal
Ceratium azoricum Cleve
— *bucephalum* (Cleve) Cleve
— *compressum* Gran
— *furca* (Ehrenberg) Claparède & Lachmann
— *fusus* (Ehrenberg) Dujardin
— *hexacanthum* Gourret
— *horridum* Gran
— *lineatum* (Ehrenberg) Cleve
— *longipes* (Bailey) Gran
— *macroceros* (Ehrenberg) Cleve
— *minutum* Jörgensen
— *tripos* (O. F. Müller) Nitzsch
— — var. *atlanticum* Ostenfeld
— — f. *balticum* Schütt
— — f. *subsalsum* Ostenfeld
Dinophysis acuminata Claparède & Lachmann
— *acuta* Ehrenberg
— *borealis* Paulsen
— *hastata* Stein
— *islandica* Paulsen
— *Lachmanni* Paulsen
— *norvegica* Claparède & Lachmann
— *Skagi* Paulsen
Exuviaella apora Schiller
— *baltica* Lohmann
— *circularis* Gaarder
— *compressa* Ostenfeld
Glenodinium danicum Paulsen
— *lenticula* (Bergh) Schiller
— — f. *asymmetrica* (Mangin) Schiller
— — f. *minor* (Paulsen) Pavillard
Goniaulax digitale (Pouchet) Kofoid
— *Ostenfeldi* (Paulsen) Paulsen
— *polyedra* Stein
— *spinifera* (Claparède & Lachmann) Diesing
— *tamarensis*, see *Ostenfeldi*
— *triacantha* Jörgensen
Gymnaster pentasterias Schütt
Gymnodinium boreale Gaarder
— *Lohmanni* Paulsen
— *simplex* (Lohmann) Kofoid & Swezy
Gyrodinium spirale (Bergh) Kofoid & Swezy
Noctiluca miliaris Suriray
Oxytoxum nanum Halldal
Paulsenella chaetoceratis (Paulsen) Chatton
Peridinium breve Paulsen
— *brevipes* Paulsen
— *conicoides* Paulsen
— *conicum* (Gran) Ostenfeld & Schmidt
— *crassipes* Kofoid
— *curvipes* Ostenfeld
— *depressum* Bailey
— *divergens* Ehrenberg
— *globulus* var. *ovatum* (Pouchet) Schiller
— — var. *quarnerense* Br. Schröder
Peridinium Grani Ostenfeld
— *leonis* Pavillard
— *Marielebourae* Paulsen
— *minusculum* Pavillard
— *oblongum* (Aurivillius) Cleve
— *oceanicum* Vanhöffen
— *pallidum* Ostenfeld
— *pellucidum* (Bergh) Schütt
— *pentagonum* Gran
— *pyriforme* Paulsen
— *roseum* Paulsen
— *Steini* Jörgensen
— *subinerme* Paulsen
— — var. *punctulatum* (Paulsen) Schiller
— *Thorianum* Paulsen
— *triquetrum* (Ehrenberg) Lebour
— *trochoideum* (Stein) Lemmermann
Phalacroma Braarudi O. Nordli
— *rotundatum* (Claparède & Lachmann) Kofoid & Michener
— *Ruudi* Braarud
Podolampas palmipes Stein
Porella perforata (Gran) Schiller
Pronoctiluca pelagica Fabre-Domerque
Prorocentrum micans Ehrenberg
Protoceratium reticulatum (Claparède & Lachmann) Bütschli
Ptychodiscus inflatus Pavillard
Pyrocystis lunula Schütt
Pyrophacus horologicum Stein

Coccolithophorids.

Acanthoica quattrospina Lohmann
Anthosphaera robusta (Lohmann) Kamptner
Braarudosphaera Bigelowi (Gran & Braarud) Deflandre
Calyptrosphaera hyalina Gaarder
Coccolithus fragilis Lohmann
— *Huxleyi* (Lohmann) Kamptner
— *leptoporus* (Murray & Blackman) Schiller
— *pelagicus* (Wallich) Schiller
Lohmannosphaera Michaelsarsi Gaarder
Rhabdosphaera stylifer Lohmann
Syracosphaera caudata Gaarder
— *mediterranea* Lohmann
— *Molischi* Schiller

Other flagellates etc.

Bodo marina Braarud
Carteria sp.
Dictyocha fibula Ehrenberg
Dinobryon pellucidum Levander
Distephanus speculum (Ehrenberg) Haeckel
— — var. *septenarius* (Ehrenberg) Jörgensen
Ebria tripartita (Schumann) Lemmermann
Euglena sp.
Eutreptia Lanowi Steuer
Fusopsis sp.
Halosphaera viridis Schmitz
Hexasterias problematica Cleve
Monosiga marina Grøntved
Pediastrum Boryanum (Turpin) Meneghini
Phaeocystis sp.
Pterosperma cristatum Schiller
— *parallelum* Gaarder
Sphæropsis lævigata Meunier
Tetrapedia emarginata Schröder

Trochiscia brachiolata (Möbius) Lemmermann
— *Clevei* Lemmermann
— *dictyon* (Jörgensen) Lemmermann
— *discoidea* Grøntved
— *Moebiusi* (Jörgensen) Lemmermann
— *Vanhoeffeni* (Jörgensen) Lemmermann

Ciliates.

Acanthostomella gracilis (Brandt) Kofoid & Campbell
— *norvegica* (Daday) Jörgensen
— *obtusa* Kofoid & Campbell
Codonellopsis lagenula (Claparède & Lachmann) Jörgensen
Coxliella ampla (Jörgensen) Brandt
Didinium parvulum Gaarder
Laboea acuminata Leegaard
— *capitata* Leegaard
— *conica* Lohmann
— *constricta* Leegaard
— *cornuta* Leegaard
— *crassula* Leegaard
— *emergens* Leegaard
— *reticulata* Leegaard
Laboea strobila Lohmann
— *vestita* Leegaard
Leprotintinnus pellucidus (Cleve) Jörgensen
Lohmanniella oviformis Leegaard
Mesodinium rubrum Lohmann
Metacylis mediterranea (Mereschkowsky) Jörgensen emend. Kofoid & Campbell
Parafavella denticulata (Ehrenberg) Kofoid & Campbell
— *edentata* (Brandt) Kofoid & Campbell
— *elegans* (Ostenfeld) Kofoid & Campbell
Parundella sp.
Ptychocylis acuta Brandt emend. Kofoid & Campbell
— *urnula* (Claparède & Lachmann) Brandt
Salpingella acuminata (Claparède & Lachmann) Jörgensen emend. Kofoid & Campbell
Stenosemella oliva (Meunier) Kofoid & Campbell
— *ventricosa* (Claparède & Lachmann) Jörgensen
Strombidium acutum Leegaard
Tintinnopsis beroidea Stein emend. Entz, Sr. emend. Jörgensen
— *campanula* (Ehrenberg) Daday emend. Kofoid & Campbell
— *parvula* Jörgensen
Woodania conicoides Leegaard.

VIII. List of Illustrations.

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IX. Tables.

The populations of plankton organisms are recorded as numbers of cells per litre.
.. indicate that the species in question was not observed at that depth.

List of Tables.

Hydrography and distribution of selected genera and species.

Table No.	Sections	Table No.	Sections	Table No.	Sections
1	A and B	5	G and H	9	Q and L
2	C	6	J and K	10	R
3	D and E	7	M and P	11	S
4	F	8	N	12	T and U

Phytoplankton tables for selected stations.

Table No.	Station	Vegetation area	Table No.	Station	Vegetation area	Table No.	Station	Vegetation area
13	A 4	I	19	S 1	VII	24	N 3	XIII
14	C 6	II	20	T 2	VIII	25	Q 14	XIV
15	E 8A	II	20	T 6	IX	26	S 7	XIV
16	E 10	II	21	U 4	IX	27	J 13	XV
17	F 1	IV	22	S 15	X	28	F 9	XVI
18	J 15	VI	23	M 1	XII	29	H 8	XVI

Table 1.

Stations		B 4	B 2	A 8	A 6	A 4	A 2
Date		5/5	4/5	4/5	4/5	3/5	3/5
	Depth (m.)						
Temperature, °C	0	8.10	8.78	8.94	9.18	9.46	9.42
	10	..	..	..	..	..	..
	20	7.80	8.77	8.92	9.24	9.31	9.41
	50	8.15	8.75	8.89	9.17	9.19	9.41
Salinity, ‰	0	35.32	35.33	35.36	35.43	35.42	35.43
	10	..	..	..	..	..	..
	20	35.30	35.35	35.35	35.39	35.42	35.42
	50	35.27	35.35	35.35	35.39	35.38	35.42
σ_t	0	27.52	27.43	27.43	27.44	27.39	27.40
	10	..	..	..	..	..	..
	20	27.56	27.45	27.42	27.40	27.42	27.40
	50	27.49	27.45	27.43	27.41	27.41	27.40
Diatoms:							
Chaetoceros	0	100	..	..	260	240	..
	10	280	..	..	340	..	..
	20	1,700	..	2,000	120	500	60
	50	260	..	1,000	80	40	..
Nitzschia	0	500	..	1,000	..	2,000	..
	10	660	+	..	..	1,000	..
	20	+	..	..	..	..	..
	50	> 1,360	..	..	..	1,500	..
Sceletonema costatum	0	> 80	..	..	..	..	..
	10	..	..	..	..	..	..
	20	5,500	..	..	..	..	..
	50	..	..	..	..	..	..
Thalassionema nitzschioides	0	860	..	..	..	..	..
	10	400	..	..	..	..	..
	20	> 640	..	..	..	..	..
	50	660	..	..	..	60	..
Thalassiosira	0	..	..	..	..	..	..
	10	220	..	..	..	..	..
	20	280	..	40	20	..	..
	50	200	..	40	..	..	..
Dinoflagellates:							
Exuviaella baltica	0	2,500	500	..	+	1,000	1,500
	10	1,000	1,000	> 80	500	1,000	1,500
	20	1,500	500	500	500	500	1,500
	50	1,000	..	..	..	+	1,500
Peridinium	0	20	20	..	100	..	..
	10	..	..	40	..	150	20
	20	> 20	..	40	40	120	..
	50	..	..	..	40	> 80	..
Gymnodiniaceae	0	29,000	29,000	13,500	36,000	34,000	> 40
	10	35,000	12,500	19,500	12,500	32,000	4,500
	20	7,000	7,500	> 19,000	23,000	23,000	4,500
	50	8,500	18,000	9,000	30,500	38,000	2,500
Coccolithophorids:							
Anthosphaera robusta	0	1,000	..	..	..	..	..
	10	500	..	..	..	..	..
	20	500	..	..	..	..	..
	50	500	..	..	..	..	..
Coccolithus Huxleyi	0	52,500	52,000	48,000	46,500	63,500	..
	10	22,000	32,500	46,000	21,000	33,000	19,500
	20	20,500	20,000	35,500	29,000	34,500	30,000
	50	26,500	29,500	55,500	47,500	27,500	28,500
C. pelagicus[1])	0	380	1,240	960	1,600	780	20
	10	200	680	1,160	1,540	1,900	500
	20	340	980	960	1,480	1,840	140
	50	340	1,080	1,100	1,940	1,800	60

[1]) Including *C. leptoporus.*

Table 1 (continued).

Stations / Date		B 4 5/5	B 2 4/5	A 8 4/5	A 6 4/5	A 4 3/5	A 2 3/5
Other forms:	Depth (m.)						
Bodo marina	0	..	..	1,000	500	3,500	60
	10	2,000	500	..	500	2,000	3,000
	20	..	500	..	..	2,000	..
	50	500	1,500	2,000	..	1,500	1,500
Lohmanniella oviformis	0	5,000	+	..	+	>60	..
	10	2,500	500	..	500	3,000	..
	20	3,000	500	500	+	>20	500
	50	2,000	4,500	500	+	1,000	..
Mesodinium rubrum	0	140	340	40	1,060	340	80
	10	80	220	260	840	775	100
	20	360	120	40	1,040	680	..
	50	100	..	60	280	80	80
Laboea	0	240	380	20	380	600	..
	10	300	80	20	380	125	20
	20	100	100	..	220	620	..
	50	300	40	20	260	160	..
Woodania conicoides	0	>520	2,500	>140	1,500	2,000	80
	10	>320	1,000	>340	>140	>175	>120
	20	200	>580	>200	1,500	3,500	..
	50	240	>220	>40	>260	..	>80

Table 2.

Stations / Date		C 2 8/5	C 4 8/5	C 6 9/5	C 8 9/5	C 10 9/5
	Depth (m.)					
Temperature, °C	0	7.72	..	8.23	8.35	9.26
	10	..	..	..	..	..
	20	7.73	..	8.13	8.23	9.25
	50	7.54	..	7.63	7.91	8.98
Salinity, ‰	0	35.26	..	35.28	35.31	35.37
	10	..	..	..	..	..
	20	35.27	..	35.28	35.29	35.36
	50	35.26	..	35.26	35.28	35.37
σ_t	0	26.54	..	27.48	27.49	27.39
	10	..	..	..	..	..
	20	26.55	..	27.49	27.48	27.38
	50	26.57	..	27.56	27.52	27.43
Diatoms:						
Chaetoceros	0	151,000	18,680	300	80	580
	10	>462,260	2,500	120	20	..
	20	199,500	14,500	760	400	60
	50	>314,680	3,000	..	80	..
Nitzschia	0	>258,500	11,500	..	..	2,500
	10	404,400	5,000	1,000	1,500	1,000
	20	239,000	18,500	500	+	..
	50	232,100	1,500	1,000	..	..
Sceletonema costatum	0	>30,000	..	6,500	..	..
	10	675,000	9,500	4,000	2,000	..
	20	110,000	2,000	>16,000	..	..
	50	290,000	10,000	4,000	1,000	..
Thalassionema nitzschioides	0	1,480	420	100	+	80
	10	6,420	240	..	..	40
	20	7,520	220	120	..	80
	50	5,440	280	100	..	340

Table 2 (continued).

Stations / Date	Depth (m.)	C 2 8/5	C 4 8/5	C 6 9/5	C 8 9/5	C 10 9/5
Thalassiosira	0	> 306,500	10,540	5,000	4,500	..
	10	289,500	11,500	8,500	4,500	..
	20	258,940	18,000	15,540	9,500	..
	50	275,000	11,000	5,580	4,060	..
Dinoflagellates:						
Exuviaella baltica	0	5,000	..	1,000	4,000	10,100
	10	1,500	1,500	4,500	1,500	9,500
	20	2,500	500	2,500	7,000	14,500
	50	1,000	2,500	..	..	500
Peridinium	0	800	2,000	2,000	3,000	..
	10	1,680	1,500	..	1,000	..
	20	160	60	500	2,000	..
	50	20	2,000	500	..	..
Gymnodiniaceae	0	5,500	10,000	22,000	12,000	20,000
	10	4,000	9,500	11,500	23,500	30,500
	20	4,000	3,500	18,000	24,000	99,000
	50	5,500	3,000	10,000	4,000	22,000
Coccolithophorids:						
Anthosphaera robusta	0	..	..	26,000	32,500	..
	10	..	..	26,000	32,000	..
	20	500	1,500	29,500	18,000	..
	50	..	..	24,000	1,500	..
Coccolithus Huxleyi	0	18,500	31,500	172,500	160,000	3,500
	10	17,500	33,000	177,000	172,500	10,000
	20	29,500	27,500	171,000	160,000	14,000
	50	12,500	24,000	89,000	19,500	32,500
C. pelagicus	0	560	1,000	3,340	3,900	20
	10	480	1,120	3,700	5,260	60
	20	400	1,180	4,640	4,740	100
	50	500	1,020	3,540	920	100
Other forms:						
Bodo marina	0	500	3,000	4,000	4,000	5,500
	10	1,500	500	6,000	7,500	5,000
	20	500	..	5,000	2,000	2,500
	50	1,500	1,000	500	..	2,500
Lohmanniella oviformis	0	..	+	5,000	1,000	1,000
	10	1,000	2,000	1,500	6,500	+
	20	500	1,000	..	2,000	..
	50	..	500	1,000	+	3,500
Mesodinium rubrum	0	300	80	140	..	260
	10	620	20	..	..	460
	20	120	40	..	..	320
	50	20	20	20	..	80
Laboea	0	420	440	200	120	220
	10	320	620	160	340	240
	20	120	260	60	20	280
	50	..	400	..	..	..
Woodania conicoides	0	500	3,500	2,000	4,500	> 40
	10	500	2,500	1,500	3,000	500
	20	500	2,000	500	500	3,000
	50	..	> 60	300	..	> 20

Table 3.

Stations / Date	Depth (m.)	D 1 13/5	E 8 A 13/5	E 10 26/5	E 8 B 26/5	E 3 27/5	E 1 27/5
Temperature, °C	0	9.02	9.22	9.05	9.20	8.88	8.80
	10	9.06	9.09	8.87	9.25	8.82	8.78
	20	8.76	9.03	8.65	8.98	8.35	8.73
	30	8.61	8.78	8.63	8.91	6.72	8.33
	50	8.22	8.57	8.61	8.15	6.43	7.12
Salinity, ‰	0	35.16	35.29	35.18	35.26	32.89	32.62
	10	35.18	35.29	35.22	35.26	32.94	32.63
	20	35.21	35.28	35.22	35.26	33.94	32.62
	30	35.25	35.29	35.23	35.25	34.25	32.76
	50	35.27	..	35.31	35.27	34.55	34.35
σ_t	0	27.25	27.33	27.28	27.31	25.51	25.31
	10	27.28	27.35	27.34	27.30	25.55	25.32
	20	27.34	27.35	27.37	27.35	26.41	25.32
	30	27.39	27.40	27.37	27.34	26.88	25.50
	50	27.48	..	27.44	27.49	27.17	26.92
O_2 %	0	..	..	..	110.8	101.8	103.5
	10	108.5	107.2	111.5	112.2	102.5	103.5
	20	106.5	106.5	106.2	108.5	108.5	103.5
	30	104.0	106.2	104.5	104.2	98.2	102.5
	50	107.0	104.0	101.5	101.2	93.5	92.2
Diatoms:							
Chaetoceros	0	..	..	> 148,380	> 267,480	1,500	..
	10	60	840	> 76,620		..	..
	20	320	140	> 50,440		..	..
	30	1,160	..	> 61,180		..	..
	50	420	..	4,200		..	..
Corethron hystrix	0	40	100	10,500	8,500	..	..
	10	40	60	7,000		..	..
	20	20	140	9,000		..	..
	30	..	60	5,000		..	..
	50	..	20	1,500		..	..
Eucampia zoodiacus	0	..	..	128,000	17,500	..	..
	10	..	..	81,000		..	..
	20	500	..	150,000		..	..
	30	..	..	82,500		..	..
	50	..	..	..		..	..
Nitzschia delicatissima	0	2,000	..	143,500	475,000	..	80
	10	5,000	..	150,000		..	..
	20	2,000	1,000	90,000		..	..
	30	..	1,000	162,000		..	..
	50	..	..	4,000		..	..
Rhizosolenia fragilissima	0	..	..	1,475,000	3,100,000	..	..
	10	..	..	1,300,000		..	..
	20	100	..	975,000		..	..
	30	2,500	..	750,000		..	..
	50	5,500	..	4,000		20	20
Thalassiosira	0	13,000	..	10,160	> 5,280	..	..
	10	15,000	..	10,000		..	..
	20	6,000	..	> 14,500		..	..
	30	5,000	..	> 15,000		..	..
	50	500	..	2,500		..	500
Dinoflagellates:							
Ceratium (furca, fusus, tripos)	0	20	..	..	..	120	200
	10	..	..	..		80	100
	20	..	..	..		60	160
	30	..	..	..		(20)	120
	50	..	..	..		..	..

Table 3 (continued).

Stations / Date	Depth (m.)	D 1 13/5	E 8 A 13/5	E 10 26/5	E 8 B 26/5	E 3 27/5	E 1 27/5
Exuviaella baltica	0	1,500	6,000	12,000	14,500	1,000	1,500
	10	2,500	3,500	8,000		1,000	500
	20	..	1,000	7,000		..	..
	30	..	500	2,500		..	1,000
	50	..	..	..		..	2,000
Peridinium	0	..	..	1,040	> 60	..	..
	10	..	..	1,080		40	..
	20	..	..	1,040		20	..
	30	..	..	520		500	..
	50	..	20	..		20	80
Gymnodiniaceae	0	77,500	46,500	17,500	13,000	2,000	500
	10	> 18,000	12,000	15,500		9,500	2,000
	20	16,500	32,500	45,000		3,500	500
	30	22,500	10,000	21,000		15,000	15,000
	50	500	8,500	10,000		6,500	9,000
Coccolithophorids:							
Anthosphaera robusta	0	1,000	4,500	5,500	26,500	5,000	..
	10	..	7,000	12,500		1,500	..
	20	11,500	7,000	22,500		1,500	500
	30	19,500	66,000	36,500		22,000	1,500
	50	16,500	36,000	13,000		3,000	2,500
Coccolithus Huxleyi	0	237,500	77,500	120,500	165,000	67,500	45,000
	10	302,500	95,000	162,500		115,000	62,500
	20	100,000	175,000	167,500		1,125,000	65,000
	30	106,000	202,500	157,500		400,000	175,000
	50	62,500	131,000	26,500		35,000	407,500
Other forms:							
Bodo marina	0	7,000	6,000	14,500	2,000	9,500	7,000
	10	> 10,000	5,000	10,000		14,500	7,500
	20	3,500	2,500	13,000		35,500	9,000
	30	3,000	1,500	11,500		30,000	33,500
	50	500	2,000	7,000		..	4,500
Small forms not classified	0	> 204,500	1,182,500	17,500	90,000	44,000	70,500
	10	> 2,685,500	3,408,500	> 84,000		507,000	43,500
	20	390,500	678,500	362,500		127,000	67,500
	30	55,000	143,000	188,000		428,500	120,500
	50	30,000	52,000	32,500		43,000	77,500
Laboea	0	20	40	1,020	600	..	20
	10	40	..	2,020		..	..
	20	40	..	60		40	..
	30	..	..	80		..	..
	50	..	..	..		20	..
Lohmanniella oviformis	0	500	1,500	3,500	6,500	3,000	1,000
	10	..	1,000	9,000		6,500	1,000
	20	2,500	6,500	13,500		..	500
	30	1,000	1,000	3,000		..	1,000
	50	500	1,000	1,000		..	+

Table 4.

Stations / Date		F 1 7/5	F 3 7/5	F 6 8/5	F 9 8/5	F 12 8/5	F 15 8/5	F 16 9/5	F 17 9/5
	Depth (m.)								
Temperature, °C	0	8.46	8.62	8.69	8.80	8.60	8.90	8.10	8.83
	10	8.40	8.35	8.66	8.43	6.85	7.76	7.68	7.57
	20	8.60	8.28	8.66	8.43	7.70	7.90	7.63	7.29
	30	8.60	8.28	8.61	8.43	8.45	7.60	7.57	6.78
	50	8.26	8.19	8.56	8.25	8.48	6.93	7.13	6.52
Salinity, ‰	0	35.27	35.33	35.33	35.31	33.50	33.71	32.60	28.16
	10	35.26	35.26	35.33	35.31	34.33	33.77	33.30	32.40
	20	35.26	35.28	35.33	35.31	34.90	34.40	33.68	32.48
	30	35.26	..	35.33	35.31	35.21	34.79	34.01	33.12
	50	35.27	35.27	35.32	35.31	35.20	34.97	34.44	34.44
σ_t	0	27.44	27.45	27.44	27.41	26.03	26.15	25.40	21.83
	10	27.45	27.45	27.45	27.47	26.93	26.36	26.00	25.32
	20	27.45	27.47	27.45	27.47	27.26	26.83	26.31	25.42
	30	27.45	..	27.45	27.47	27.39	27.19	26.58	25.99
	50	27.45	27.48	27.45	27.50	27.38	27.43	26.98	27.07
O_2 %	0	108.5	108.5	101.5	114.5	107.0	107.0	105.5	..
	10	108.5	111.5	101.5	113.5	103.5	104.5	107.5	..
	20	106.5	107.0	102.0	113.5	106.5	106.8	108.0	..
	30	106.5	105.0	101.5	111.2	106.0	108.0	104.5	..
	50	105.5	103.8	101.5	110.0	..	92.0	106.0	..
Diatoms:									
Asterionella japonica	0	41,500	21,500	..	4,880	..	..	..	..
	10	7,000	54,500	..	12,000	..	..	..	..
	20	900	62,500	..	13,000	..	..	..	..
	30	2,660	18,000	..	15,000	7,500	..	..	..
	50	3,780	79,500	..	5,000	..	..	..	..
Cerataulina Bergoni	0	2,180	3,500	700	77,000	..	..	..	..
	10	4,680	12,500	1,800	97,500	..	..	..	..
	20	1,060	2,040	..	132,500	240	..	..	..
	30	3,620	6,000	..	138,500	> 520	..	..	300
	50	2,260	> 700	..	46,500	> 1,900	40	..	..
Chaetoceros	0	45,940	> 49,780	500	> 95,360	> 380	300	..	252,500
	10	127,280	> 130,960	560	> 103,320	2,040	..	..	1,000
	20	80,740	> 69,020	..	> 191,820	3,720	60,000	..	17,000
	30	69,900	> 125,080	..	> 250,760	196,580	35,200	..	6,000
	50	57,400	73,240	..	96,660	234,940	..	..	..
Nitzschia	0	30,500	15,500	2,000	139,000	> 100	..	..	..
	10	60,000	14,000	60	83,500	> 1,040	..	..	..
	20	25,000	7,800	..	115,500	> 2,540	2,000	..	..
	30	41,000	> 4,700	..	147,000	12,000	10,500	500	..
	50	20,000	7,600	..	146,500	91,500	500	500	..
Rhizosolenia fragilissima	0	320	+	..	16,500	17,500	..	..	..
	10	160	3,500	..	10,500	1,000	..	..	160
	20	760	..	..	43,500	86,500	53,000	..	3,000
	30	1,160	8,500	..	15,500	103,000	342,500	80	..
	50	1,820	..	..	5,000	87,500	..	1,000	..
R. Stolterfothi	0	6,900	17,500	1,700	8,960	..	..	..	..
	10	5,740	23,500	200	29,000	..	..	..	..
	20	7,400	7,200	..	26,000	..	..	..	..
	30	4,760	7,700	..	25,000	1,260	..	..	..
	50	10,520	2,660	..	9,900	120	..	..	..
Sceletonema costatum	0	48,500	+	..	..	1,500	..	..	ca. 1,600,000
	10	118,000	2,000	..	..	+	..	..	14,000
	20	116,500	+	..	..	7,000	..	..	3,500
	30	72,500	2,000	..	3,500	> 73,000	6,500	..	1,500
	50	64,500	9,500	..	..	95,000	> 40	..	..
Thalassionema nitzschioides	0	6,500	140	..	> 80	..	..	..	..
	10	1,140	..	..	..	..	..	..	..
	20	1,560	260	..	..	2,000	..	..	..
	30	660	300	..	..	940	..	..	..
	50	720	160	..	> 320	170	..	..	..
Thalassiosira	0	125,500	88,800	3,000	> 5,000	..	..	..	..
	10	109,500	171,600	80	6,400	..	..	..	..
	20	101,500	153,500	..	7,200	1,000	..	..	..
	30	201,000	120,100	..	20,400	5,900	80	..	..
	50	136,500	61,100	..	15,500	18,320	..	..	..

Table 4 (continued).

Stations		F 1	F 3	F 6	F 9	F 12	F 15	F 16	F 17
Date		7/5	7/5	8/5	8/5	8/5	8/5	9/5	9/5
	Depth (m.)								
Dinoflagellates:									
Ceratium (furca, fusus, tripos).	0	..	..	..	100	180	260	180	20
	10	60	40	40	160	40	460	380	120
	20	60	40	..	60	20	20	420	160
	30	20	20	60	100	40	20	80	140
	50	20	..	..	60	..	..	80	40
Dinophysis	0	..	..	..	..	100	1,360	> 160	940
	10	..	..	..	..	100	200	120	40
	20	..	..	..	..	160	160	60	80
	30	..	..	..	..	120	..	60	..
	50	20	..	..	..	..	..	20	..
Exuviaella baltica	0	500	2,500	5,000	5,000	2,500	500	500	2,000
	10	3,000	500	3,500	2,000	500	2,500	..	..
	20	3,000	..	..	500	2,000	1,500	1,000	1,000
	30	1,000	500	..	..	2,500	+	500	..
	50	1,500	..	..	..	1,000	1,000	..	..
Peridinium	0	120	40	..	20	> 720	> 3,360	500	> 5,740
	10	200	60	..	200	> 1,480	60	40	1,020
	20	140	40	..	60	2,860	> 220	20	> 420
	30	160	40	..	80	2,280	> 260	> 140	80
	50	40	..	..	180	300	80	140	..
Gymnodiniaceae	0	6,000	> 1,320	8,020	8,500	10,560	30,020	11,500	20,620
	10	7,500	1,020	7,040	16,120	16,620	4,500	8,000	36,000
	20	10,500	2,080	..	8,680	12,680	4,500	8,500	21,000
	30	4,620	1,140	..	8,200	15,640	500	14,000	2,000
	50	3,120	720	..	1,600	..	..	..	..
Coccolithophorids:									
Anthosphaera robusta	0	..	+	500	..	1,000	1,000	500	..
	10	500	..	..	..	2,000	1,500	..	..
	20	..	..	..	..	7,500	2,000	500	..
	30	..	..	..	500	6,000	14,500	..	..
	50	..	..	..	..	300	..	13,500	..
Coccolithus Huxleyi	0	3,500	8,500	14,500	5,000	55,500	30,000	1,000	..
	10	6,500	2,500	23,000	13,500	50,000	115,500	14,500	2,000
	20	10,000	1,000	..	1,500	76,500	337,500	8,500	8,000
	30	7,500	3,000	..	5,000	71,000	217,000	32,000	2,500
	50	6,500	..	..	..	59,000	1,500	57,500	5,000
Other forms:									
Bodo marina	0	..	+	3,000	..	6,000	4,000	2,000	7,000
	10	..	..	6,000	..	4,000	15,000	10,000	12,000
	20	..	..	..	500	3,500	4,000	8,500	8,500
	30	500	..	..	..	3,500	1,500	4,000	4,000
	50	..	..	..	500	3,000	1,000	1,000	..
Laboea	0	260	40	160	1,160	1,560	1,880	260	160
	10	20	20	80	200	400	100	80	60
	20	..	20	..	40	100	180	80	20
	30	60	..	..	..	60	120	20	..
	50	..	..	..	..	100	..	..	..
Lohmanniella oviformis	0	..	2,000	..	1,500	2,500	15,500	2,000	4,000
	10	1,500	> 120	500	3,000	500	3,000	4,000	1,500
	20	500	..	..	3,500	5,000	4,000	..	1,000
	30	1,500	> 60	..	1,000	1,000	1,500	1,000	+
	50	500	> 40	..	2,000	+	500	1,000	..
Mesodinium rubrum	0	3,500	2,500	1,360	660	1,220	5,500	> 580	2,500
	10	500	120	600	1,320	280	40	40	80
	20	20	> 220	..	40	360	160	20	200
	30	..	40	..	40	20	200	40	160
	50	..	..	..	20	80	..	220	..
Woodania conicoides	0	3,000	4,500	2,000	1,500	1,500	2,500	1,000	1,500
	10	20	..	220	1,500	> 20	2,000	+	> 60
	20	..	..	..	..	500	1,000	..	500
	30	..	500	..	..	500	500	..	..
	50	..	..	..	..	500	20	..	..

Table 5.

Stations / Date	Depth (m.)	G 5 11/5	G 4 7/5	G 3 11/5	G 2 7/5	G 1 12/5	H 16 5/5	H 11 4/5	H 8 4/5	H 5 3/5	H 3 3/5	H 1 3/5
Temperature, °C	0	8.60	8.10	8.29	8.10	8.43	8.09	7.78	8.25	7.75	8.20	7.25
	10	..	8.06	..	8.10	..	7.97	7.70	8.36	7.62	6.92	7.27
	20	8.11	8.08	8.29	8.09	8.43	8.01	7.77	8.43	6.34	7.03	5.84
	30	..	8.02	..	8.09	..	7.99	7.16	7.90	6.46	5.84	5.88
	50	8.05	7.82	8.29	8.11	8.43	7.92	7.14	7.38	6.46	5.46	5.92
Salinity, ‰	0	35.20	35.15	35.10	34.99	34.95	34.80	35.22	34.96	32.79	31.48	32.45
	10	..	35.17	..	34.99	..	34.80	35.21	35.05	34.42	32.46	33.02
	20	35.21	35.19	35.13	34.98	34.94	34.81	35.21	35.13	34.70	33.74	33.73
	30	..	35.17	..	34.98	..	34.81	35.21	35.24	34.85	33.89	33.93
	50	35.23	35.20	35.13	34.98	34.93	..	35.21	35.25	34.90	34.50	34.28
σ_t	0	27.36	27.40	27.33	27.27	27.19	27.13	27.49	27.22	25.60	24.51	25.40
	10	..	27.42	..	27.27	..	27.15	27.51	27.27	26.89	25.45	25.84
	20	27.45	27.43	27.35	27.27	27.18	27.15	27.50	27.33	27.30	26.23	26.59
	30	..	27.43	..	27.27	..	27.15	27.58	27.50	27.39	26.76	26.74
	50	27.46	27.48	27.35	27.27	27.17	..	27.59	27.57	27.44	27.24	27.02
O_2 %	0	..	105.0	..	103.5	..	107.5	109.0	120.0	108.0	..	117.5
	10	..	105.0	..	103.5	..	101.5	111.0	120.5	120.5	107.0	107.5
	20	..	106.0	..	105.0	..	109.0	111.5	122.5	94.5	107.0	97.5
	30	..	106.0	..	102.5	..	106.0	111.0	112.0	96.5	95.5	101.5
	50	..	104.0	..	..	..	100.0	100.5	103.0	94.0	94.5	..
Diatoms:												
Asterionella japonica	0	..	140	+	+	..	..	..	..	..	..	..
	10	..	1,720	40	..	4,600	..	..	..	..	..	..
	20	..	660	1,200	..		..	..	..	..	..	..
	30		280		..		..	..	..	..	..	..
	50	..	720	+	..	8,000	..	..	..	..	..	..
Chaetoceros	0	280	3,420	3,120	300	30,500	1,820	10,480	222,040	4,920	..	..
	10	580	5,470	1,620	40	>32,540	6,660	5,820	261,500	56,960	..	..
	20	460	10,440	1,840	980		480	3,340	213,060	6,220	..	240
	30		3,020		920		340	14,960	21,760	11,680	..	140
	50	..	600	1,020	320	>10,560	100	120	5,660	200	..	..
Leptocylindrus danicus	0	..	260	..	680	..	..	220	107,500	6,000	..	..
	10	..	..	..	..	2,260	..	80	58,500	11,500	..	..
	20	..	..	120	..		440	40	47,000	11,000	..	640
	30		..		..		..	..	5,740	19,500	..	260
	50	..	..	..	..	2,500	..	..	340	7,500	60	28,000
Nitzschia	0	..	500	660	540	29,500	6,500	11,000	57,480	2,500	..	..
	10	80	..	500	160	32,300	7,500	4,000	54,500	33,160	..	..
	20	20	> 1,100	180	140		6,500	2,500	23,200	1,280	..	500
	30		1,260		120		1,760	1,000	14,780	700	..	..
	50	20	140	..	40	> 8,860	20	500	340	40	..	..
Rhizosolenia fragilissima	0	..	..	..	..	..	..	..	420	320	..	500
	10	..	..	..	..	200	..	..	45,500	2,620	..	1,000
	20	..	..	..	..		..	..	35,000	220	60	..
	30		..		..		..	..	1,520	260	..	..
	50	..	..	..	..	..	..	..	100	..	..	..
Sceletonema costatum	0	..	..	24,000	..	..	48,000	3,000	7,000	..	..	..
	10	..	..	..	..	46,500	35,000	20,000	2,500	3,500	..	..
	20	..	..	> 3,000	..		57,000	4,000	6,000	..	..	..
	30		100		..		4,500	1,000	5,500	..	..	80
	50	..	..	2,500	..	7,500	340	..	..	..	..	..
Thalassionema nitzschioides	0	360	80	680	490	4,000	360	..	..	..	..	..
	10	40	..	720	660	2,320	1,480	..	80	300	..	..
	20	20	..	> 1,120	920		15,000	..	..	60	..	..
	30		40		440		3,500	..	..	340	..	40
	50	..	340	60	560	..	..	..	..	..	80	..
Thalassiosira	0	..	24,550	31,740	10,000	155,500	409,000	39,500	50,200	..	..	..
	10	..	61,560	> 25,040	4,740	195,000	357,500	36,500	26,500	300	..	..
	20	340	59,340	> 29,800	3,040		333,020	32,000	17,500	140	..	..
	30		39,160		2,560		146,000	26,500	980	80	..	..
	50	..	1,520	21,500	135,000	1,640	2,160	500	320	..	..	..

Table 5 (continued).

Stations / Date		G 5 $^{11}/_{5}$	G 4 $^{7}/_{5}$	G 3 $^{11}/_{5}$	G 2 $^{7}/_{5}$	G 1 $^{12}/_{5}$	H 16 $^{5}/_{5}$	H 11 $^{4}/_{5}$	H 8 $^{4}/_{5}$	H 5 $^{3}/_{5}$	H 3 $^{3}/_{5}$	H 1 $^{3}/_{5}$
	Depth (m.)											
Dinoflagellates:												
Ceratium (furca, fusus, tripos)	0	..	..	..	..	20	..	20	100	500	240	40
	10	20	..	..	..	..	..	20	200	220	300	200
	20	20	20	..	..		..	40	160	..	40	..
	30		..		..		..	20	20	20	..	..
	50	..	..	..	..	40	..	..	..	..	..	20
Exuviaella baltica	0	1,000	..	6,000	1,000	2,000	..	39,000	3,000	2,000	40	500
	10	+	1,000	+	1,000	1,500	500	37,000	500	1,500	..	2,500
	20	1,500	500	1,000	500		..	32,500	1,000	..	1,000	..
	30		1,000		..		..	39,500	..	..	20	..
	50	..	..	500	1,000	4,500	..	..	..	..	..	..
Peridinium	0	..	20	20	..	400	200	500	120	1,360	1,520	> 40
	10	..	20	40	..	> 200	220	560	1,760	280	500	200
	20	20	20	40	..		140	1,000	20	160	80	100
	30		20		..		20	540	60	> 220	..	60
	50	..	20	520	..	500	20	..	..	..	620	40
Gymnodiniaceae	0	6,060	4,660	4,040	4,020	3,500	2,840	16,200	2,020	18,000	17,520	37,500
	10	560	4,160	5,580	5,520	23,240	7,500	17,780	3,500	10,520	38,500	27,500
	20	5,600	2,680	3,060	7,500		1,520	12,080	5,500	15,000	28,520	18,000
	30		5,020		5,500		2,000	10,340	4,000	6,040	31,500	8,520
	50	560	3,540	3,520	2,500	15,500	1,000	10,500	1,500	2,000	10,000	4,000
Coccolithophorids:												
Coccolithus Huxleyi	0	6,000	8,000	43,500	9,000	3,500	2,500	6,000	3,500	2,000	2,000	3,000
	10	500	6,000	65,500	27,000	7,000	2,000	22,500	8,500	9,000	3,000	4,500
	20	3,500	5,000	30,000	19,000		3,000	16,000	9,500	2,000	4,000	> 20
	30		2,500		33,000		2,500	8,000	13,000	> 40	500	1,000
	50	1,500	2,500	> 15,000	26,500	11,000	3,500	500	..	500	..	..
Other forms:												
Bodo marina	0	..	..	500	500	500	..	17,500	500	3,000	6,500	4,000
	10	..	500	1,000	..	1,000	1,000	12,000	..	1,500	3,000	6,000
	20	..	1,500	500	1,500		500	6,500	..	500	2,500	..
	30		..		..		..	1,000	..	..	..	..
	50	..	..	..	..	1,000	..	..	..	..	..	..
Laboea	0	60	40	20	100	60	340	400	80	600	120	20
	10	..	140	40	120	340	80	..	140	100	60	320
	20	100	40	20	..		..	40	120	140	60	60
	30		60		40		..	180	60	100	..	..
	50	..	20	20	500	..	20	..	..	20	..	..
Lohmanniella oviformis	0	+	..	500	1,000	2,000	1,000	1,000	..	1,000	1,500	2,000
	10	500	40	2,500	500	1,500	500	500	..	3,500	5,500	1,000
	20	1,000	40	> 140	180		> 80	..	60	..	> 80	500
	30		..		1,500		..	500	1,000	500	500	1,500
	50	..	40	..	500	1,000	1,500	500	..	..	..	500

Table 6.

Stations / Date	Depth (m.)	J 15 7/5	J 13 7/5	J 11 8/5	J 9 8/5	J 7 8/5	J 5 8/5	J 3 8/5	J 1 9/5	K 7 9/5	K 5 9/5	K 3 9/5	K 1 9/5
Temperature, °C	0	8.55	8.67	8.22	8.38	8.45	8.50	8.85	8.44	8.56	8.80	9.23	9.60
	10	7.53	8.20	8.10	8.14	7.97	7.63	7.80	7.79	8.03	8.22	8.22	8.00
	20	7.53	8.04	7.90	8.01	7.80	7.49	7.57	7.67	7.79	6.20	6.96	..
	50	7.45	7.75	7.29	7.69	6.83	7.12	7.25	6.95	6.80	7.05	5.80	5.75
Salinity, ‰	0	34.81	34.94	34.99	34.94	35.10	35.01	35.16	35.16	35.21	33.91	31.15	27.86
	10	34.81	34.96	35.01	35.03	35.08	35.10	35.17	35.14	35.19	34.45	31.85	30.48
	20	34.83	34.96	34.99	35.03	35.07	35.08	35.19	35.14	35.21	34.79	33.44	29.43
	50	34.81	35.05	35.01	35.08	35.10	35.14	35.19	35.14	35.10	35.16	34.34	34.11
σ_t	0	27.07	27.14	27.25	27.10	27.30	27.23	27.28	27.34	27.36	26.32	24.09	21.48
	10	27.22	27.23	27.29	27.30	27.36	27.43	27.46	27.43	27.44	26.83	24.79	21.48
	20	27.23	27.25	27.30	27.32	27.37	27.43	27.50	27.45	27.49	27.38	26.22	..
	50	27.23	27.36	27.41	27.40	27.54	27.53	27.55	27.56	27.55	27.55	27.08	26.90
O_2 %	0	..	..	..	..	..	..	..	..	..	..	..	..
	10	102.0	..	..	..	..	..	..	..	..	..	..	..
	20	102.0	..	..	..	..	..	..	..	..	..	..	..
	50	101.0	..	..	..	..	..	..	..	..	..	..	..
P_2O_5 mg./m³	0	0	0	4	..	..	2—4	4—7	7	..	0—2	2—4	..
	10	7	7—10	4	..	..	4	4	4—7	..	0—2	4—7	4—7
	20	0	7—10	2	..	..	7	4	4—7	4	2	2	2—4
	50	0	2—4	4—7	..	..	10	..	7	20	2	4—7	4
Diatoms:													
Chaetoceros	0	1,020	..	12,900	53,400	..	..	2,000	..	1,220	1,080	..	..
	10	160	180	1,720	38,540	..	..	..	..	22,060	10,640	..	..
	20	680	100	1,780	55,540	..	..	..	..	19,160	1,120	..	..
	50	140	160	1,300	2,680	..	500	500	80	7,760	400	..	..
Nitzschia	0	1,000	> 160	1,640	4,500	..	..	..	..	..	..	..	..
	10	1,500	> 300	..	12,000	..	..	..	..	..	..	..	..
	20	> 40	60	1,000	4,000	..	..	..	..	..	..	..	..
	50	700	> 180	3,000	..	..	20	..	..	1,500	20	..	..
Rhizosolenia fragilissima	0	348,000	..	..	..	..	..	..	..	..	14,500	..	..
	10	185,500	..	..	..	..	..	..	..	..	5,000	..	..
	20	149,000	..	..	..	..	..	..	..	..	..	..	..
	50	99,500	..	..	..	..	..	..	..	20	20	..	..
Thalassiosira	0	19,000	5,000	136,160	27,500	..	..	..	..	500	2,500	..	..
	10	21,000	7,500	62,020	27,060	..	..	..	..	..	..	..	..
	20	22,500	8,000	26,000	22,500	..	..	..	..	..	..	20	..
	50	10,500	1,540	6,020	3,180	..	40	..	..	20	500	..	..
Dinoflagellates:													
Ceratium (furca, fusus, tripos)	0	..	..	..	..	..	..	..	..	80	80	200	140
	10	..	..	..	20	..	..	..	60	80	160	260	..
	20	..	..	..	20	..	20	..	100	160	..	..	120
	50	..	..	..	..	..	40	40	..	..	..	20	..
Exuviaella baltica	0	6,500	63,500	112,000	130,000	19,000	24,500	22,500	500	5,000	11,000	2,000	1,500
	10	1,500	110,500	110,000	3,000	8,000	4,500	3,000	1,500	1,500	1,000	500	..
	20	1,500	2,000	1,500	6,000	10,500	2,500	1,500	> 20	1,000	500	1,000	1,000
	50	1,000	1,500	5,000	..	..	..	..	..	1,000	..	> 60	..
Peridinium	0	2,060	..	40	..	20	..	..	500	120	300	..	2,520
	10	140	..	..	..	80	20	20	100	40	120	60	..
	20	500	..	..	20	20	..	20	100	20	120	120	1,000
	50	1,000	500	20	..	100	20	60	20	20	80	180	..
Gymnodiniaceae	0	26,500	107,520	15,000	33,000	..	..	20	..	14,000	69,500	49,000	68,000
	10	13,000	409,000	21,500	6,000	20	..	..	..	10,000	24,000	40,500	6,000
	20	24,500	72,500	3,500	3,000	..	520	..	..	7,500	17,000	21,000	83,000
	50	15,500	24,500	1,000	1,000	..	..	..	..	7,000	10,500	14,500	20,000
Coccolithophorids:													
Coccolithus Huxleyi	0	73,500	30,500	30,500	35,500	..	..	> 20	..	500	5,500	3,500	500
	10	6,500	38,000	23,000	25,500	..	500	..	..	1,500	7,000	..	..
	20	6,000	20,500	13,500	12,500	1,000	..	500	..	..	..	4,500	1,500
	50	13,500	13,500	6,000	2,500	..	..	500	..	..	..	500	500

Table 6 (continued).

Stations		J 15	J 13	J 11	J 9	J 7	J 5	J 3	J 1	K 7	K 5	K 3	K 1
Date		7/5	7/5	8/5	8/5	8/5	8/5	8/5	9/5	9/5	9/5	9/5	9/5
	Depth (m.)												
Other forms:													
Bodo marina	0	1,500	9,000	..	..	6,000	..	..	..	1,500	4,500	4,500	17,500
	10	500	9,500	..	..	3,000	500	500	..	2,500	5,000	8,000	..
	20	..	16,000	..	4,000	12,500	..	..	..	1,000	..	500	15,500
	50	..	2,000	..	..	3,500	..	..	..	..	500	..	500
Small forms not classified	0	50,000	146,500	10,500	14,500	52,500	1,208,000	8,000	43,000	15,500	57,500	33,500	30,000
	10	3,000	136,500	5,500	5,000	19,000	293,000	7,000	10,000	4,000	7,000	36,000	3,000
	20	91,000	34,500	3,000	12,000	23,500	29,000	2,000	2,000	3,500	2,000	8,000	91,000
	50	3,000	10,000	500	2,500	8,500	..	1,500	2,000	4,000	2,000	5,500	3,000
Laboea	0	80	12,660	..	..	..	..	..	..	20	..	..	1,520
	10	..	220	..	..	..	..	..	..	..	..	..	..
	20	..	..	..	..	..	..	..	..	60	..	..	40
	50	..	120	..	..	..	..	..	..	..	..	..	..
Lohmanniella oviformis	0	..	80	..	..	500	..	500	..	1,500	1,000	..	1,000
	10	> 40	..	..	..	..	..	..	..	500	5,000	1,000	..
	20	2,000	..	..	..	60	..	..	..	..	..	> 20	8,500
	50	..	120	..	..	..	..	100	1,000	500	500	> 20	..
Mesodinium rubrum	0	20	1,500	..	..	..	..	..	..	..	1,000	..	..
	10	..	2,500	..	..	..	..	..	..	..	..	..	..
	20	..	..	..	..	..	..	..	..	..	20	..	..
	50	..	..	..	..	..	..	..	..	40	..	..	..
Woodania conicoides	0	2,000	8,000	..	..	..	..	..	..	40	1,500	..	1,500
	10	..	17,000	..	..	..	..	..	..	..	..	..	..
	20	..	..	..	..	..	..	..	..	20	..	..	2,000
	50	..	80	..	..	..	..	..	..	..	20	..	..

Table 7.

Stations / Date	Depth (m.)	M 9 3/5	M 5 3/5	M 3 3/5	M 1 2/5	P 4 2/5	P 2 2/5
Temperature, °C	0	8.93	7.99	7.70	8.42	8.03	8.00
	10	6.28	7.55	7.61	7.80	7.62	7.80
	20	6.96	6.19	7.31	7.45	7.40	7.70
	30	5.90	6.18	6.32	7.20	7.35	7.60
	50	5.55	6.22	6.48	6.92	7.23	7.36
Salinity, ‰	0	24.25	29.18	33.89	32.56	32.94	30.90
	10	30.72	32.01	34.02	33.10	33.24	31.24
	20	33.31	34.70	34.11	36.62	33.51	32.88
	30	34.05	34.92	34.65	33.96	33.71	33.30
	50	34.42	35.01	35.05	34.04	33.89	33.60
σ_t	0	18.77	22.74	26.46	25.32	25.67	24.08
	10	24.17	25.02	26.59	25.83	25.97	24.38
	20	26.12	27.32	26.70	26.30	26.21	25.58
	30	26.84	27.48	27.25	26.59	26.38	26.29
	50	27.16	27.56	27.54	26.69	26.53	26.29
O_2 %	0	..	..	..	..	99	100
	10	..	96	95	..	100	103
	20	..	82	102	..	101	101
	30	..	91	102	..	95	101
	50	..	90	99	..	101	101
P_2O_5, mg./m³	0	..	..	2—4	..	0—2	0—2
	10	..	..	..	..	0—2	?
	20	..	..	..	..	2	?
	30	..	..	..	..	4—7	?
	50	..	..	20	..	0—2	?
Diatoms:							
Asterionella japonica	0	..		..	2,000	1,500	..
	10	..		..	500	..	..
	20	..	..	..	+	6,000	..
	30		..		> 260		
	50	..	..	..	..	..	2,000
Chaetoceros	0	140		> 540	3,740	> 13,340	3,560
	10	..		+	46,500	37,220	200
	20	..	..	4,240	164,860	> 25,720	> 8,100
	30		..		15,560		
	50	1,500	..	500	21,000	> 14,880	> 920
Nitzschia	0	..		500	500	..	> 1,520
	10	2,000		..	500	..	> 680
	20	500	..	..	2,160	> 20	1,500
	30		..		..		
	50	..	..	..	1,000	..	1,000
Rhizosolenia fragilissima	0	..		6,000	..	..	..
	10	..		+	..	..	..
	20	..	..	5,500	..	..	..
	30		..		..		
	50	..	..	1,500	..	..	4,000
Dinoflagellates:							
Ceratium (furca, fusus, tripos)	0	20		120	..	40	20
	10	80		140	20	160	140
	20	100	420	120	220	60	180
	30		..		100		
	50	20	..	..	..	140	..
Exuviaella baltica	0	3,500		1,500	..	+	1,500
	10	500		3,000	500	+	1,000
	20	5,000	500	3,500	1,500	2,000	1,000
	30		3,500		..		
	50	1,000	..	..	1,500	500	500

Table 7 (continued).

Stations / Date	Depth (m.)	M 9 3/5	M 5 3/5	M 3 3/5	M 1 2/5	P 4 2/5	P 2 2/5
Peridinium	0	2,300		720	> 80	> 460	640
	10	360		620	> 280	1,120	> 148
	20	..	> 340	1,640	> 180	> 260	> 260
	30		> 240		140		
	50	560	..	20	100	100	> 120
Gymnodiniaceae	0	9,000		7,500	1,500	..	3,500
	10	9,000		4,000	4,000	500	2,000
	20	17,000	3,500	3,500	5,500	1,500	+
	30		8,500		1,000		
	50	5,500	..	500	3,000	1,500	2,500
Coccolithophorids:							
Coccolithus Huxleyi	0	500		5,000	..	..	500
	10	500		6,500	..	+	500
	20	..	5,500	2,000	..	500	500
	30		2,000		..		
	50	500	..	..	500	..	..
Other forms:							
Bodo marina	0	14,500		2,000	500	1,000	..
	10	5,500		..	1,000	..	500
	20	..	..	..	4,500	1,000	500
	30		..		500		
	50	500	..	..	..	1,000	..
Small forms not classified	0	14,500		11,500	5,000	1,000	8,500
	10	8,500		6,000	11,500	500	13,000
	20	4,500	4,500	7,500	8,000	3,500	1,000
	30		5,000		7,000		
	50	2,500	1,500	2,500	1,000	500	2,000
Laboea	0	60		60	180	..	..
	10	80		..	240	..	..
	20	260	..	..	> 60	..	..
	30		..		20		
	50	..	..	..	..	..	..
Lohmanniella oviformis	0	5,000		10,500	6,000	4,000	9,000
	10	2,000		+	3,000	5,500	3,500
	20	2,000	3,000	1,500	6,500	4,000	1,500
	30		2,000		6,000		
	50	1,000	500	+	2,000	3,500	1,000

Table 8.

Stations / Date	Depth (m.)	N 1 3/5	N 3 3/5	N 5 3/5	N 7 2/5	N 9 4/5	N 8 4/5
Temperature, °C	0	8.35	6.26	7.92	8.03	9.16	9.52
	10	6.20	6.28	7.36	..	8.07	9.52
	20	5.73	5.95	6.41	7.87	5.27	5.48
	30	5.64	5.87	5.75	5.86	..	5.56
	50	..	6.22	5.48	5.66	5.57	..
Salinity, ‰	0	24.02	23.22	24.20	24.36	18.04	22.16
	10	29.34	30.39	27.30	..	24.31	24.99
	20	32.65	32.01	33.60	32.09	31.60	31.18
	30	33.37	33.44	34.40	33.12	..	33.10
	50	..	34.31	..	34.34	34.11	..
σ_t	0	18.66	18.28	18.86	18.97	13.91	17.06
	10	23.10	23.91	21.25	..	18.93	19.26
	20	25.75	25.22	26.42	25.03	24.98	24.62
	30	26.33	26.36	27.13	26.10	..	26.12
	50	..	27.00	..	27.10	26.92	..
O_2 %	0	99.5	92.5	100	99.5	99	101
	10	99	99	99.5	..	100.5	104
	20	93.5	97	104.5	76.5	90	..
	30	92.5	98	94.5	96	..	93
	50	..	97.5	..	95.5	92.5	..
Diatoms:							
Chaetoceros	0	(40)	700	120	> 520	..	..
	10	..	80	380	10,000	5,500	1,580
	20		160	..	+	1,060	
	30	..	..	..	200	..	..
	50		..		240		
Leptocylindrus danicus	0	..	2,500	500	6,000	1,000	..
	10	..	1,000	4,500	10,000	1,500	1,000
	20		28,000	3,140	40	..	
	30	..	13,500	10,500	2,500	1,000	4,500
	50		1,000		25,500		
Nitzschia	0	2,500	4,620	..	5,000	> 10,500	> 300
	10	..	..	4,000	2,500	3,000	4,000
	20		180	520	..	500	
	30	..	500	..	500	500	..
	50		..		..		
Dinoflagellates:							
Ceratium (furca, fusus, tripos)	0	60	20	..	60	20	40
	10	80	120	100	120	80	60
	20		..	20	20	..	
	30	..	..	..	..	..	..
	50		..		20		
Dinophysis	0	1,000	840	(40)	2,160	4,000	3,960
	10	1,040	880	1,240	1,820	3,680	4,480
	20		20	..	100	40	
	30	20	20	..	..	80	60
	50		(20)		..		
Exuviaella baltica	0	..	..	..	1,000	2,500	1,000
	10	+	4,500	..	2,000	500	..
	20		1,500	..	500	..	
	30	..	..	..	..	..	..
	50		..		..		
Gymnodiniaceae	0	> 15,000	19,000	..	46,000	20,000	15,000
	10	32,500	57,500	59,000	9,000	19,000	12,000
	20		16,000	10,000	12,500	13,000	
	30	5,500	7,500	12,500	7,500	12,500	3,500
	50		20,000		3,500		

Table 8 (continued).

Stations / Date	Depth (m.)	N 1 3/5	N 3 3/5	N 5 3/5	N 7 2/5	N 9 4/5	N 8 4/5
Peridinium	0	1,660	2,700	..	> 560	> 660	1,580
	10	3,520	520	1,780	1,260	4,900	6,700
	20		60	40	180	80	
	30	120	40	60	40	40	100
	50		20		40		
Other forms:							
Bodo marina	0	12,500	13,000	..	15,000	11,500	9,000
	10	3,000	4,000	10,500	13,000	19,500	1,000
	20		1,000	500	2,000	2,000	
	30	1,000	1,000	2,500	500	..	1,500
	50		1,500		500		
Small forms not classified	0	> 27,000	> 70,000	> 7,000	> 42,500	> 9,000	4,000
	10	> 42,500	> 95,000	> 74,000	> 44,500	> 50,000	31,000
	20		> 48,000	> 90,000	> 26,500	..	
	30	> 17,500	> 12,500	> 35,000	> 37,500	> 9,000	500
	50		> 66,500		> 10,500		
Lohmanniella oviformis	0	500	+	..	3,000	3,000	4,500
	10	..	2,500	..	5,500	6,500	12,500
	20		1,000	6,000	2,000	500	
	30	1,500	500	6,000	1,500	500	40
	50		500		1,500		

Table 9.

Stations / Date		Q 24 6/5	Q 22 6/5	Q 20 6/5	Q 18 6/5	Q 16 5/5	Q 14 5/5	Q 12 5/5
	Depth (m.)							
Temperature, °C	0	8.15	7.80	7.60	7.53	7.74	7.95	7.96
	10	7.90	7.80	7.63	7.46	7.75	7.93	7.91
	20	7.63	7.60	7.43	7.40	7.68	7.90	7.91
	50	..	7.54	7.30	7.17	7.22	7.00	6.79
Salinity, ‰	0	33.55	34.61	..	34.67	34.85	35.01	35.01
	10	33.75	34.63	34.61	34.69	34.87	35.01	35.01
	20	34.43	34.65	34.67	34.69	34.87	35.01	35.01
	50	..	34.65	34.70	34.69	34.90	35.03	35.07
σ_t	0	26.14	27.04	..	27.10	27.21	27.31	27.31
	10	26.33	27.05	27.07	27.12	27.23	27.32	27.32
	20	26.90	27.07	27.12	27.13	27.24	27.32	27.32
	50	..	27.08	27.16	27.16	27.33	27.46	27.52
O_2 %	0	..	..	..	..	..	..	..
	10	..	..	..	..	..	..	..
	20	..	..	..	..	..	..	..
	50	..	..	..	..	..	..	..
P_2O_5, mg./m³	0	0	4	2—4	90	10—15	4	..
	10	4	2	4—7	100	20	2—4	..
	20	4	2—4	2—4	7—10	20—35	2	..
	50	..	4—7	10	10	10	10	..
Diatoms:								
Asterionella japonica	0	35,000	3,000	..	..	..	..	..
	10	740,000	2,500	..	2,500	..	..	..
	20	18,500	5,500	..	..	..	..	..
	50		> 160	2,000	..	..	..	..
Chaetoceros	0	52,620	300	..	..	..	..	..
	10	> 267,400	320	1,500	40	40	..	..
	20	..	..	..	80	..	..	..
	50		> 140	340	500	20	..	..
Eucampia zoodiacus	0	..	..	..	..	..	..	..
	10	..	..	..	..	..	..	..
	20	..	..	..	..	..	..	..
	50		..	..	..	..	..	..
Guinardia flaccida	0	..	..	..	..	..	..	..
	10	..	..	..	..	..	..	..
	20	..	..	..	..	..	..	..
	50		..	..	..	..	..	..
Nitzschia	0	23,500	1,000	..	..	..	..	..
	10	> 311,850	2,780	1,500	1,080	..	..	..
	20	> 4,100	2,000	500	..	180	..	..
	50		7,000	..	500	60	..	..
Rhizosolenia fragilissima	0	> 80	100		..	..	..	..
	10	15,500	..	..	..	..	..	..
	20	2,500	..	..	180	..	..	..
	50		..	..	500	..	..	..
R. imbricata var. Shrubsolei	0	..	..	..	..	..	..	..
	10	1,000	..	..	..	..	..	..
	20	..	..	..	..	..	..	..
	50		..	..	10	10	..	..
Thalassiosira	0	6,500	..	..	..	..	..	..
	10	> 25,300	..	80	..	..	..	..
	20	> 3,500	100	40	..	..	..	..
	50		40	60	80	20	..	..
Dinoflagellates:								
Ceratium (furca, fusus, tripos)	0	..	..	..	20	..	..	40
	10	..	20	..	..	..	..	120
	20	20	..	..	..	..	..	160
	50		..	..	..	40	..	40

Table 9.

Q 10 5/5	Q 8 5/5	Q 6 5/5	Q 4 4/5	Q 2 4/5	L 7 4/5	L 5 4/5	L 3 4/5	L 1 3/5	Depth (m.)
7.68	7.23	7.23	7.50	7.43	7.28	8.09	7.81	6.57	0
7.68	7.24	7.23	7.50	7.40	7.10	8.21	7.50	5.70	10
7.67	7.23	7.23	7.50	7.17	6.77	7.61	5.76	5.55	20
6.60	5.45	5.43	5.90	6.68	..	7.69	5.56	5.54	50
5.01	34.90	34.78	34.67	34.70	34.67	..	26.26	32.16	0
5.01	34.90	34.79	34.67	34.67	34.70	31.87	32.61	33.17	10
5.03	34.92	34.81	34.67	34.65	34.72	..	34.04	33.64	20
5.03	34.83	34.81	34.69	34.70	..	35.25	34.65	34.34	50
7.35	27.33	27.23	27.11	27.15	27.14	..	20.47	25.25	0
7.35	27.33	27.24	27.11	27.12	27.11	24.81	25.49	26.16	10
7.36	27.34	27.26	27.11	27.13	27.23	..	26.84	26.55	20
7.52	27.51	27.50	27.43	27.25	..	27.53	27.35	27.11	50
..	..	..	..	..	..	..	..	..	0
92	..	..	..	..	..	..	..	..	10
90	..	..	..	..	..	..	..	..	20
85	..	..	..	..	..	..	..	..	50
..	0—2	4	..	2—4	..	..	..	10	0
..	4	2—4	..	..	..	..	..	..	10
..	0—2	7—10	..	..	..	0—2	..	..	20
..	2—4	0—2	..	..	..	..	..	..	50
..	..	..	..	..	..	..	..	..	0
..	..	..	..	..	..	..	..	..	10
..	..	..	..	..	..	..	..	..	20
..	..	..	..	..		..	..	..	50
..	..	..	..	..	..	220	..	60	0
..	..	60	..	80	..	..	..	..	10
..	80	200	..	200	..	140	..	..	20
..	1,439,400	1,050,460	225,500	+		460	..	..	50
..	..	..	..	200	..	..	..	..	0
..	..	..	..	1,620	..	..	..	..	10
..	..	..	..	4,300	..	..	..	..	20
..	80	..	..	70,500		..	..	..	50
..	..	..	..	60	..	..	..	..	0
..	..	..	..	260	..	..	..	..	10
..	..	..	..	320	..	..	..	..	20
..	..	..	20	51,000		..	..	..	50
..	..	..	..	..	..	..	1,500	> 20	0
..	..	..	100	..	..	..	..	..	10
..	..	..	..	..	..	..	..	..	20
..	20,000	3,500	2,500	1,500		..	> 20	..	50
..	..	..	..	..	..	..	..	..	0
..	..	..	..	160	..	> 20	..	..	10
..	..	..	..	..	..	1,240	..	..	20
..	..	..	..	60		640	..	..	50
..	..	..	50	60	320	..	..	..	0
..	..	..	40	40	550	..	..	..	10
..	..	..	..	240	290	..	..	..	20
..	..	..	480	520		110	..	..	50
..	..	..	..	..	..	..	..	..	0
..	..	..	..	..	..	..	..	..	10
..	..	..	..	..	..	..	..	..	20
40	..	..	..	..		80	20	..	50
200	340	120	320	100	300	260	180	180	0
140	360	160	180	180	280	340	40	..	10
260	380	60	240	80	420	20	..	..	20
..	..	100	..	60		..	..	..	50

Table 9.

Stations Date		Q 24 6/5	Q 22 6/5	Q 20 6/5	Q 18 6/5	Q 16 5/5	Q 14 5/5	Q 12 5/5
	Depth (m.)							
Exuviaella baltica	0	25,000	4,000	1,000	18,000	15,000	1,500	..
	10	+	4,000	5,000	22,500	4,000	3,000	> 80
	20	..	2,000	4,500	19,500	1,500	1,500	500
	50		..	2,500	500	500	..	..
Peridinium	0	> 9,980	40	..	40	60	20	..
	10	1,480	..	..	20	20	..	..
	20	220	80	..	120	..	..	> 20
	50		20	..	40	40	320	40
Gymnodiniaceae	0	1,500	9,500	8,500	4,500	20,500	2,000	1,000
	10	> 11,500	..	12,000	13,000	9,000	2,060	1,000
	20	1,500	3,000	11,000	9,500	9,500	1,500	+
	50		..	6,000	1,500	1,000	4,000	500
Coccolithophorids:								
Coccolithus Huxleyi	0	..	2,000	500	..	..	1,500	..
	10	..	500	500	500	..	500	..
	20	..	..	500	..	1,500	..	..
	50		500	1,500	..	..	..	..
Other forms:								
Bodo marina	0	4,500	12,500	12,500	16,000	500	..	..
	10	3,000	..	15,500	6,000	4,500	..	..
	20	1,000	..	14,000	20,000	3,000	..	..
	50		..	8,500	61,000	3,500	..	..
Small forms not classified	0	> 60,000	1,000	..	21,000	160,000	..	2,000
	10	..	17,000	..	27,500	130,000	..	..
	20	9,000	14,000	..	10,500	112,500	..	..
	50		7,000	..	..	500	..	100
Laboea	0	..	..	80	20	20	60	..
	10	..	..	20	40	..	20	..
	20	..	..	..	..	..	20	..
	50		..	..	..	..	..	..
Lohmanniella oviformis	0	3,500	1,000	..	500	500	..	..
	10	2,500	..	..	500	2,500	..	..
	20	+	3,500	..	500	+	1,000	..
	50		+	1,000	1,000	> 60	..	..

Table 9.

10 5/5	Q 8 5/5	Q 6 5/5	Q 4 4/5	Q 2 4/5	L 7 4/5	L 5 4/5	L 3 4/5	L 1 3/5	Depth (m.)
500	1,500	500	1,500	1,000	57,500	3,500	1,000	500	0
00	1,000	1,000	4,500	1,500	57,500	3,000	1,500	2,000	10
500	1,000	+	2,500	500	39,000	2,500	..	..	20
500	> 60	+	..	+		..	..	..	50
40	160	> 140	160	20	340	2,500	3,560	620	0
40	280	> 160	140	60	360	160	> 500	1,100	10
20	320	> 40	140	60	100	40	400	500	20
20	80	220	40	1,500		100	20	20	50
500	1,000	2,000	> 20	6,500	3,520	27,500	15,500	9,000	0
500	2,500	4,000	> 100	3,500	> 160	8,500	22,000	5,500	10
000	1,000	1,000	> 40	2,500	4,000	26,500	11,000	4,000	20
00	6,500	1,000	1,500	1,500		6,500	+	500	50
.	1,000	1,500	2,500	1,000	..	1,000	..	500	0
000	1,000	500	1,000	5,500	1,000	2,000	12,500	500	10
.	1,000	1,000	..	4,000	1,000	1,500	..	..	20
.	..	..	+	1,000		500	+	..	50
.	..	..	..	1,500	..	8,500	6,000	2,500	0
.	..	..	..	500	500	11,000	1,000	..	10
.	..	..	..	1,000	..	..	..	1,500	20
.	..	..	..	..		..	..	..	50
000	500	..	..	..	> 6,000	127,500	..	21,000	0
000	..	..	..	..	1,000	44,500	..	2,500	10
500	..	..	..	..	..	..	13,000	4,500	20
.	3,500	..	..	..		2,000	500	3,500	50
.	40	..	340	160	..	220	360	60	0
.	20	..	140	..	..	20	> 60	100	10
.	20	..	160	..	..	..	..	..	20
.	..	..	..	..		..	..	..	50
.	1,500	500	1,000	20	1,000	8,000	13,000	2,000	0
500	500	2,000	..	> 40	1,500	500	3,000	1,000	10
.	> 80	3,500	1,000	100	> 460	500	2,000	1,000	20
.	> 100	> 120	1,000	+		1,500	500	..	50

Table 10.

Stations / Date	Depth (m.)[1]	R 1 8/5	R 3 8/5	R 5 7/5	R 7 7/5	R 9 7/5	R 11 7/5	R 13 6/5	R 15 6/5	R 17 6/5
Temperature, °C	0	7.64	8.40	8.60	8.67	8.28	8.29	8.30	9.01	8.92
	10	7.50	8.03	8.00	8.02	8.21	8.18	7.78	8.38	8.11
	20	7.50	7.83	7.95	7.86	7.90	7.88	7.62	8.00	7.48
	50	7.50	6.78	6.48	6.32	7.84	7.88	6.35	7.95	7.35
Salinity, ‰	0	34.10	34.77	34.92	34.88	34.85	34.60	34.62	33.59	32.10
	10	34.14	34.71	34.94	34.88	34.80	34.60	34.62	33.68	32.23
	20	34.11	34.74	34.90	34.90	34.85	34.60	34.61	34.03	32.99
	50	34.42	34.81	34.88	34.86	34.84	..	34.61	34.02	33.15
σ_t	0	26.64	27.05	27.13	27.10	27.14	26.94	26.95	26.04	24.88
	10	26.69	27.06	27.25	27.20	27.11	26.95	27.03	26.20	25.11
	20	26.67	27.12	27.23	27.24	27.19	27.00	27.04	26.53	25.79
	50	26.68	27.32	27.42	27.42	27.20	..	27.21	26.54	25.95
P, µg.-atom/L	0	0.4	0.2	0.2	0.2	0.15	0.05	0.05	0.0	0.0
	10	0.4	0.2	0.2	0.2	0.15	0.05	0.05	0.0	0.0
	20	0.4	0.2	0.2	0.3	0.15	0.10	0.0	0.0	0.0
	50	0.4	0.5	0.4	0.4	0.05	0.10	0.1	0.0	0.0
N_{NO_3}, µg.-atom/L	0	3.5	0.8	0.5	0.5	1.0	1.5	1.0	5.0	10.0
	10	3.5	0.8	0.5	0.5	1.5	1.0	1.0	4.5	10.0
	20	3.5	0.8	0.5	0.5	1.5	1.0	1.5	10.0	10.0
	50	3.5	4.0	1.0	1.0	1.5	1.0	1.0	10.0	10.0
Diatoms:										
Asterionella japonica	0	1,000	..	..	..	..	..	..		..
	10	6,300	..	..	..	..	..	..	10,400	..
	20	2,800	..	..	..	..	..	..	155,500	600
	50	900	..	..	100	..	..	..	548,800	5,500
Chaetoceros	0	2,200	..	..	..	..	..	..		4,200
	10	1,900	..	..	..	100	..	..	31,400	6,000
	20	600	800	..	..	..	200	..	72,200	6,600
	50	2,100	18,400	..	2,000	200	..	1,500	167,000	8,100
Nitzschia	0	2,500	400	100	100	1,100	..	600		..
	10	1,800	100	300	..	500	..	..	200	..
	20	3,300	100	..	100	..	600	700	100	900
	50	2,200	600	..	300	200	800	1,600	800	800
Rhizosolenia imbricata var. Shrubsolei	0	..	..	..	5,300	7,500	..	600		..
	10	..	..	..	4,000	6,500	..	600	..	..
	20	..	..	..	2,800	2,600	..	200	..	..
	50	..	500	100	36,300	3,500	..	500	..	..
Sceletonema costatum	0	4,000	..	..	..	..	..	..		..
	10	17,200	..	..	..	..	..	..	..	..
	20	22,100	..	..	..	..	..	..	1,400	700
	50	22,800	..	..	..	..	..	..	5,400	6,600
Thalassiosira	0	100	..	..	..	..	..	..		..
	10	600	..	..	..	..	..	..	..	..
	20	300	..	..	..	..	..	..	..	..
	50	200	..	..	..	..	..	100	1,700	..
Dinoflagellates:										
Ceratium (furca, fusus, tripos)	0	100	100	300	1,000	500	100	500		..
	10	..	200	600	1,000	300	100	100	..	..
	20	..	..	300	1,000	500	..	300	..	..
	50	..	100	100	..	300	..	100	100	100
Exuviaella baltica	0	1,200	104,500	800	37,500	3,900	3,500	16,400		2,600
	10	1,800	35,200	1,000	5,100	4,500	4,600	13,800	700	1,400
	20	1,200	3,000	800	3,200	5,900	4,800	21,900	100	300
	50	1,800	400	300	900	19,200	4,400	1,000	..	300
Peridinium	0	200	1,200	..	..	200	..	200		1,000
	10	1,000	1,600	200	..	300	..	600	600	700
	20	2,000	600	..	..	100	..	..	600	900
	50	1,000	..	..	100	..	..	100	300	200

[1]) In this table not all the "50 m. samples" are taken from this depth. They represent the deepest samples at each station, viz., R_1 — 28 m., R_{3-7} — 50 m., R_9 — 35 m., R_{11} — 30 m., R_{13} — 45 m., R_{15} — 28 m., R_{17} — 24 m.

Table 10 (continued).

Stations / Date		R 1 8/5	R 3 8/5	R 5 7/5	R 7 7/5	R 9 7/5	R 11 7/5	R 13 6/5	R 15 6/5	R 17 6/5
	Depth (m.)									
Gymnodiniaceae	0	100	3,000	..	..	1,000	500	700		600
	10	600	2,000	100	..	1,500	500	..	1,500	700
	20	1,000	200	..	..	..	..	100	1,000	400
	50	1,500	300	100	8,500	500	..	200	600	400
Other forms:										
Bodo marina	0	700	7,200	200	200	800	100	300		8,000
	10	1,900	11,800	500	200	600	600	200	7,200	15,000
	20	1,000	10,500	500	100	800	300	100	1,200	9,500
	50	1,900	700	500	200	900	200	200	1,100	8,500
Small forms not classified	0	12,000	29,500	6,500	5,000	32,000	6,500	..		..
	10	13,000	101,500	10,000	10,500	57,000	7,000	..	500	..
	20	16,500	144,500	18,500	15,500	72,500	8,500	100	1,500	..
	50	9,500	15,500	14,000	12,500	73,500	19,500	1,500	1,000	6,000
Laboea	0	200	900	100	..	400	100	400		600
	10	100	400	200	..	100	600	800	400	..
	20	100	700	300	..	200	800	2,300	100	..
	50	100	..	..	500	..	200	1,300	300	500
Lohmanniella oviformis	0	100	..	..	..	..	100	100		..
	10	100	..	..	100	100	100	400	500	..
	20	600	..	..	..	..	..	100	2,000	1,900
	50	500	..	..	..	..	..	600	2,400	2,200

Table 11.

Stations / Date		S 1 8/5	S 3 8/5	S 5 9/5	S 7 9/5	S 9 9/5	S 11 10/5	S 13 10/5	S 15 10/5
	Depth (m.)[1]								
Temperature, °C	0	8.53	9.21	9.12	9.14	9.14	10.00	9.67	8.87
	10	8.03	8.04	8.60	9.00	8.75	9.26	9.56	8.57
	20	7.97	7.52	8.30	8.61	7.96	8.11	8.20	8.20
	50	7.93	7.47	..	8.60	6.62	8.02	8.12	8.15
Salinity, ‰	0	34.20	34.45	34.61	34.55	34.36	34.40	33.58	33.31
	10	34.16	34.52	34.60	34.56	34.39	34.58	33.58	33.32
	20	34.18	34.52	34.63	34.56	34.38	34.72	34.13	33.49
	50	34.21	34.52	..	34.58	34.38	34.74	34.23	33.54
σ_t	0	26.58	26.66	26.81	26.76	26.62	26.50	26.92	25.83
	10	26.63	26.91	26.88	26.79	26.70	26.77	25.93	25.89
	20	26.65	26.98	26.94	26.85	26.82	27.05	26.59	26.08
	50	26.68	26.98	..	26.87	27.00	27.09	26.67	26.13
P, μg.-atom/L	0	0.2	0.4	0.2	0.3	0.0	0.05	0.05	0.05
	10	0.2	0.4	0.2	0.3	0.0	0.05	0.05	0.05
	20	0.2	0.4	0.2	0.3	0.1	0.05	0.05	0.05
	50	0.3	0.5	..	0.3	0.1	0.05	0.05	0.10
N_{NO_3}, μg.-atom/L	0	0.5	1.0	0.5	0.5	0.5	1.0	1.5	5.0
	10	0.5	1.5	0.5	0.5	0.5	1.0	1.5	4.0
	20	0.5	4.0	0.5	0.5	0.5	1.0	1.0	4.0
	50	1.0	5.0	..	0.0	0.5	1.0	1.0	4.0
Diatoms:									
Asterionella japonica	0	27,100	..	100	..	..	..	..	500
	10	51,600	..	300	..	..	..	..	..
	20	183,300	..	1,200	..	..	..	100	3,500
	50	397,000	500		..	..	..	900	1,500
Chaetoceros	0	18,600	..	..	200	..	200	100	44,200
	10	11,500	..	..	..	..	400	..	35,600
	20	38,500	..	8,900	100	..	54,500	2,000	48,800
	50	37,600	100		..	2,600	39,500	10,900	91,700

[1]) In this table not all the "50 m. samples" are taken from this depth. They represent the deepest samples at each station, viz., S_1 — 45 m., S_3 — 50 m., S_7 — 27 m.. S_9 — 42 m., S_{11} — 38 m., S_{13} — 30 m., S_{15} — 36 m.

Table 11 (continued).

Stations		S 1	S 3	S 5	S 7	S 9	S 11	S 13	S 15
Date		8/5	8/5	9/5	9/5	9/5	10/5	10/5	10/5
	Depth (m.)								
Nitzschia	0	3,200	1,200	400	400	200	..	300	300
	10	3,700	100	4,500	700	100	..	700	100
	20	7,700	500	> 3,100	1,500	..	> 4,000	> 600	> 800
	50	27,200	500		1,200	1,600	> 2,300	> 1,500	500
Rhizosolenia imbricata var. Shrubsolei	0	..	..	1,400	24,000	900	100	..	200
	10	..	..	1,100	23,800	200	200	..	100
	20	..	..	2,500	23,700	500	500	200	100
	50	..	..		30,400	10,700	1,200	100	..
Sceletonema costatum	0	29,000	600	..	..	..	..	..	..
	10	70,600	..	..	..	..	..	..	..
	20	254,700	..	..	..	..	..	..	..
	50	1,440,000	..		..	..	..	..	..
Thalassionema nitzschioides	0	3,400	..	600	..	..	..	..	..
	10	4,300	400	400	..	..	..	..	..
	20	7,300	400	700	..	..	..	..	400
	50	6,800	400		..	..	..	..	600
Thalassiosira	0	4,700	..	..	..	..	..	..	200
	10	9,700	..	500	..	..	..	..	100
	20	28,400	..	100	..	..	..	400	400
	50	53,600	..		..	..	700	200	300
Dinoflagellates:									
Ceratium (furca, fusus, tripos)	0	..	..	..	..	200	100	100	200
	10	..	..	..	600	200	100	..	200
	20	..	..	..	100	100	..	400	200
	50	..	..		100	..	..	400	300
Exuviaella baltica	0	1,600	10,600	300	2,200	400	6,000	2,200	200
	10	2,800	750	..	2.400	400	11,200	1,300	300
	20	2,900	500	..	1,900	400	400	800	200
	50	2,000	700		2,800	200	900	200	200
Peridinium	0	4,200	300	600	400	400	700	200	300
	10	3,200	..	200	200	400	300	..	200
	20	3,600	500	300	200	100	400	200	500
	50	5,600	100		500	100	900	100	500
Gymnodiniaceae	0	3,500	..	700	500	1,000	600	100	500
	10	1,300	..	1,500	..	500	200	500	200
	20	2,600	..	500	100	600	900	100	100
	50	2,100	100		1,000	2,200	1,100	2,200	600
Coccolithophorids:									
Coccolithus Huxleyi	0	..	..	..	..	..	..	..	100
	10	..	..	..	..	500	200	..	100
	20	..	..	..	..	..	..	700	..
	50	..	..		..	..	..	..	..
Other forms:									
Bodo marina	0	2,900	600	700	500	1,100	600	1,000	11,000
	10	4,600	2,200	500	500	700	3,600	400	11,000
	20	5,800	1,400	1,000	400	700	2,600	1,900	11,000
	50	5,400	1,500		500	1,700	1,300	1,900	7,000
Laboea	0	..	100	1,800	500	200	400	200	..
	10	100	100	1,700	400	100	500	300	100
	20	..	..	200	..	100	500	200	..
	50	..	..		100	100	100	500	..
Small forms not classified	0	8,500	24,000	1,000	4,500	14,500	9,000	4,500	2,000
	10	7,500	9,500	3,500	12,500	9,500	9,500	6,000	4,500
	20	11,500	8,000	..	18,000	11,500	6,500	7,500	6,500
	50	12,500	11,000		13,500	6,500	9,500	5,500	12,000
Lohmanniella oviformis	0	200	..	1,800	600	100	300	200	300
	10	1,000	..	3,300	400	100	400	..	300
	20	600	100	100	500	200	700	600	400
	50	..	100		300	700	300	600	400

Table 12.

Stations / Date		T 2 4/5	T 4 5/5	T 6 5/5	U 2 7/5	U 4 7/5	U 6 7/5	U 8 5/5
	Depth (m.)							
Temperature, °C	0	8.58	8.75	8.59	8.78	9.65	10.11	9.56
	10	..	8.76	8.59	8.77	9.60	9.79	9.55
	20	..	8.75	8.59	8.78	9.57	9.76	9.55
Salinity, ‰	0	34.42	34.63	34.56	34.43	34.91	34.96	35.09
	10	..	34.64	34.52	34.43	34.91	34.96	35.01
	20	..	34.60	34.54	34.43	34.91	34.96	35.01
σ_t	0	26.75	26.89	26.86	26.73	26.96	26.92	27.11
	10	..	26.90	..	..	26.96	..	..
	20	..	26.88	..	..	26.97	..	..
Diatoms:								
Asterionella japonica	0	18,000	200	100	400	..	..	..
	10		..			..		
	20		500			..		
Chaetoceros	0	147,000	..	5,600	1,200	..	..	1,000
	10		..			..		
	20		..			500		
Nitzschia	0	144,000	95,900	19,100	11,700	> 6,500	> 1,000	> 2,700
	10		30,000			12,100		
	20		42,300			10,000		
Rhizosolenia imbricata var. Shrubsolei	0	..	200	1,500	200	100	..	1,000
	10		700			..		
	20		500			..		
Thalassionema nitzschioides	0	13,000	4,400	100	3,100	200	400	200
	10		4,600			..		
	20		3,700			200		
Thalassiosira	0	18,000	200	600	300	200	..	500
	10		500			300		
	20		..			200		
Dinoflagellates:								
Ceratium (furca, fusus, tripos)	0	..	300	..	..	200	..	500
	10		100			100		
	20		300			100		
Exuviaella baltica	0	5,000	2,300	1,500	..	1,500	7,000	300
	10		6,000			2,000		
	20		3,500			1,500		
Peridinium	0	400	500	400	300	1,300	900	600
	10		2,900			1,500		
	20		1,000			2,700		
Gymnodiniaceae	0	4,000	..	..	4,000	2,800	2,000	2,000
	10		..			7,100		
	20		..			600		
Other forms:								
Bodo marina	0	2,000	..	1,000	2,000	8,000	7,500	4,500
	10		500			14,500		
	20		1,500			4,500		
Small forms not classified	0	3,000	1,000	1,000	18,000	1,700	8,000	..
	10		1,000			14,500		
	20		1,000			11,500		
Laboea	0	1,200	500	400	100	1,200	500	600
	10		200			1,500		
	20		300			1,500		
Lohmanniella oviformis	0	200	..	500	300	100	..	..
	10		..			..		
	20		100			200		

Phytoplankton tables for selected stations.

Table 13.

St. A 4, 3. May 1948.

Depth in metres	0	10	20	50	100	150	200	500
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:								
Asteromphalus heptactis	..	..	(20)	..	..	..	..	..
Chaetoceros affinis var. Willei	..	..	480	..	..	..	..	..
— atlanticus	180	..	..	..	..	..	..	..
— borealis f. concavicornis	60	..	100	..	..	..	180	..
— decipiens	..	..	..	40	..	80	..	..
— sp. (Hyalochaete)	..	..	..	..	1,000	..	..	..
Coscinodiscus curvatulus	..	..	..	..	..	20	..	..
— decrescens	..	..	..	..	20	..	..	..
— excentricus	..	..	100	..	..	..	..	..
— lineatus	..	..	20	..	..	..	..	..
Dactyliosolen mediterraneus	(1,600)	(2,900)	(+)	(> 1,440)	(880)	(> 1,340)	(> 900)	..
Hemidiscus cuneiformis var. ventricosa	..	..	..	20	..	..	..	..
Melosira sulcata	..	..	..	140	..	..	..	..
Nitzschia closterium	..	..	..	500	..	> 40	..	..
— delicatissima	2,000	1,000	..	1,000	..	240	> 40	..
Rhizosolenia Stolterfothi	..	..	240	..	..	100	..	..
Roperia tessellata	..	(25)	..	..	..	..	..	..
Thalassionema nitzschioides	..	..	..	60	..	80	..	..
Centric diatoms not classified	60	..	..	..	60	..	..	..
Dinoflagellates:								
Ceratium fusus	..	..	20	..	20	..	..	..
— lineatum	..	..	20	20	..	20	20	..
Dinophysis borealis	..	125	20	..	40	40	..	..
— hastata	..	..	..	..	..	..	20	..
— Lachmanni	..	..	..	80	..	..	..	..
Exuviaella baltica	1,000	1,000	500	+	2,000	1,000	500	..
— circularis	..	..	20	40	20	..	..	..
Glenodinium lenticula	..	..	20	..	..	..	..	..
Goniaulax Ostenfeldi	40	125	40	..	20	120	..	..
— spinifera	..	325	380	180	..	160	+	..
Gymnodinium boreale	40	25	20	60	20	40	20	..
Gymnodiniaceae	34,000	32,000	23,000	38,000	32,500	19,500	18,500	..
Oxytoxum nanum	..	500	500	..	..	..	1,000	..
— sp.	..	25	..	..	..	..	..	..
Peridinium brevipes	..	75	60	> 40	40	..	20	..
— globulus var. ovatum	..	..	..	..	..	..	20	..
— — var. quarnerense	..	..	60	40	20	20	..	..
— trochoideum	..	..	..	..	60	..	..	..
— sp.	..	75	20	..	..	..	60	..
Phalacroma rotundatum	..	..	..	..	..	20	20	..
Porella perforata	..	100	60	80	20	..	..	..
Protoceratium reticulatum	100	25	..	..	..	..	..	..
Dinoflagellates not classified	180	3,000	> 80	1,000	40	180	1,000	..
Athecate dinoflagellates	20	175	100	280	200	180	140	..
Cysts of dinoflagellates	..	..	..	..	..	20	..	..
Coccolithophorids:								
Acanthoica sp.	..	500	..	..	..	..	..	..
Calyptrosphaera hyalina	1,000	> 50	..	..	..	..	..	..
Coccolithus fragilis	..	..	..	..	..	..	60	..
— Huxleyi	63,500	33,000	34,500	27,500	29,500	64,000	35,500	1,000
— leptoporus	..	..	..	..	..	20	..	..
— pelagicus	780	1,900	1,840	1,800	2,000	2,080	2,080	120
Syracosphaera mediterranea	80	50	..	40	20	20	40	..

Table 13 (continued).

Depth in metres	0	10	20	50	100	150	200	500
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Other flagellates, etc.:								
Bodo marina	3,500	2,000	2,000	1,500	1,000	2,000	1,000	..
Dictyocha fibula	..	..	..	..	20	..	..	..
Distephanus speculum	..	..	20	..	..	..	..	..
— — var. septenarius	..	..	..	..	..	..	10	..
Flagellates and monades not classified	1,500	5,500	2,500	2,000	14,000	10,000	7,500	..
Ciliates:								
Codonellopsis lagenula	..	25	..	..	..	..	20	..
Didinium parvulum	2,000	..	> 20	..	..	..	..	..
Laboea conica	600	125	620	160	200	40	20	..
— constricta	..	..	..	..	..	20	..	..
Lohmanniella oviformis	> 60	3,000	> 20	1,000	2,000	3,500	1,000	..
Mesodinium rubrum	340	775	680	80	..	60	20	..
Parafavella elegans (empty loricae)	..	(25)	..	..	..	..	..	..
Woodania conicoides	2,000	> 175	3,500	..	> 40	40	..	..
Ciliates not classified	100	75	60	1,500	1,000	80	..	..

Table 14.

St. C6, 9. May 1948.

Depth in metres	0	10	20	50	100	150	500
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:							
Chaetoceros debilis	..	..	560	..	..	..	..
— decipiens	160	..	..	..	..	..	..
— densus	..	..	200	..	..	..	..
— sp. (Hyalochaete)	140	120	..	+	..	..	..
Corethron hystrix	260	180	200	60	20	..	..
Coscinodiscus radiatus	..	(20)	..	..	20	..	..
— sp.	20	..	..	..	..	..	..
Eucampia zoodiacus	..	..	..	1,000	..	..	..
Fragilaria nana	..	..	..	+	..	..	..
Melosira sulcata	..	..	..	..	..	..	20
Nitzschia closterium	..	..	500	..	..	..	..
— delicatissima	..	1,000	..	1,000	500	..	..
Sceletonema costatum	6,500	4,000	>16,000	4,000	..	..	..
Thalassionema nitzschioides	100	..	120	100	20	..	..
Thalassiosira bioculata	3,000	5,500	15,500	5,500	3,000	500	..
— gravida	2,000	3,000	40	80	..	..	..
Centric diatoms not classified	..	500	..	..	..	..	..
Pennate diatoms not classified	2,500	1,500	40	1,500	20	..	..
Dinoflagellates:							
Exuviaella baltica	1,000	4,500	2,500	..	..	..	..
— circularis	20	20	..	..	..	..	..
Goniaulax Ostenfeldi	..	..	..	..	40	..	..
Gymnodinium boreale	20	20	..	500	..	..	..
Gymnodiniaceae	22,000	11,500	18,000	10,000	2,500	3,000	..
Oxytoxum nanum	..	..	..	1,000	..	..	..
Peridinium minusculum	2,000	..	500	500	..	..	..
Phalacroma Braarudi	..	..	>20	>500	..	..	..
Cysts of dinoflagellates	..	..	..	..	..	..	20
Coccolithophorids:							
Acanthoica quattrospina	500	..	500	..	..	..	..
Anthosphaera robusta	26,000	26,000	29,500	24,000	3,000	..	..
Calyptrosphaera hyalina	3,000	4,500	5,000	2,000	..	..	..
Coccolithus Huxleyi	172,500	177,000	171,000	89,000	32,500	1,500	..
— pelagicus	3,340	3,700	4,640	3,540	1,920	400	..
Ophiaster hydroideus	..	500	1,000	3,500	..	..	..
Syracosphaera caudata	..	..	..	8,500	2,500	..	..
— mediterranea	40	60	20	..	..	..	..
— Molischi	..	..	..	2,000	2,000	..	..
Coccolithophorids not classified	1,000	1,000	..	..	..	..	..
Other flagellates, etc.:							
Bodo marina	4,000	6,000	5,000	500	..	1,000	..
Distephanus speculum	..	..	10	10	..	..	..
Halosphaera viridis	..	..	..	..	..	20	..
Flagellates and monades not classified	29,000	44,500	53,000	4,000	2,500	1,000	..
Ciliates:							
Acanthostomella gracilis	40	20	80	..	..	..	..
— — (empty loricae)	..	(20)	..	..	..	..	..
Didinium parvulum	1,000	500	1,500	6,500	500	..	..
Laboea conica	200	160	60	..	..	..	..
— sp.	..	..	..	..	40	..	..
Lohmanniella oviformis	5,000	1,500	6,000	1,000	500	1,000	..
Mesodinium rubrum	140	..	..	20	..	..	..
Parafavella sp. (empty loricae)	..	..	(40)	(40)	..	..	..
Woodania conicoides	2,000	1,500	500	300	..	..	..
Ciliates not classified	40	..	40	>180	40	..	..

Table 15.

St. E 8 A, 13. May 1948.

Depth in metres	0	10	20	30	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:					
Chaetoceros convolutus	..	..	40	..	..
— debilis	..	300	100	..	..
— decipiens	..	540	..	..	..
Corethron hystrix	100	60	140	60	20
Fragilaria nana	..	..	..	..	2,000
Melosira sulcata	..	..	..	..	120
Nitzschia delicatissima	..	..	1,000	1,000	..
Centric diatoms not classified	..	20	1,000	..	1,500
Pennate diatoms not classified	500	20	500	500	1,500
Dinoflagellates:					
Exuviaella baltica	6,000	3,500	1,000	500	..
— circularis	20	40	..	..	..
Gymnodinium Lohmanni	..	..	..	20	..
Gymnodiniaceae	46,500	12,000	32,500	10,000	8,500
Oxytoxum nanum	..	..	..	500	500
Peridinium pellucidum	..	..	..	..	20
Phalacroma Braarudi	..	..	..	>40	>20
Dinoflagellates not classified	..	500	..	..	..
Athecate dinoflagellates	..	..	60	60	>80
Coccolithophorids:					
Acanthoica quattrospina	..	..	1,500	..	..
Anthosphaera robusta	4,500	7,000	7,000	66,000	36,000
Calyptrosphaera hyalina	17,500	11,500	5,500	2,000	500
Coccolithus Huxleyi	77,500	95,000	175,000	202,500	131,000
— pelagicus	840	1,200	2,100	5,520	6,800
Ophiaster hydroideus	500	..	3,500	..	..
Syracosphaera caudata	>11,000	>7,500	3,500	>5,500	2,000
— mediterranea	100	100	60	120	160
— Molischi	+	+	9,000	>4,500	>500
Coccolithophorids not classified	..	500	..	..	..
Other flagellates, etc.:					
Bodo marina	6,000	5,000	2,500	1,500	2,000
Monosiga marina	..	..	1,500	500	..
Flagellates not classified	7,500	8,500	..	..	..
Flagellates and monades not classified	1,175,000	3,400,000	677,000	142,500	52,000
Ciliates:					
Acanthostomella gracilis	40	..	..	..	..
Didinium parvulum	..	..	..	1,000	..
Laboea conica	40	..	..	..	..
— sp.	..	..	20	40	..
Lohmanniella oviformis	1,500	1,000	6,500	1,000	1,000
Mesodinium rubrum	20	..	..	..	..
Parafavella edentata	..	20	..	(20)	(20)
Woodania conicoides	3,500	+	..	..	20
Ciliates not classified	..	..	..	..	20

Table 16.

St. E10, 26. May 1948.

Depth in metres	0	10	20	30	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:					
Achnanthes sp.	660	2,000	+	8.500	..
Cerataulina Bergoni	> 100	4,500	2,000	..	..
Chaetoceros atlanticus	200	..	..	..	..
— borealis	60	60	100	..	..
— — f. concavicornis	7,000	6,500	2,500	4,500	1,500
— compressus	1,000	..	..	..	..
— convolutus	800	1,780	240	400	200
— debilis	115,500	54,000	41,500	52,000	2,500
— decipiens	> 2,140	> 2,260	880	> 1,140	..
— diadema	2,000	..	..	..	..
— difficilis?	2,500	..	..	..	..
— laciniosus	..	..	> 80	..	..
— radicans	9,000	4,000	1,500	+	..
— similis	1,500	..	..	..	..
— spp. (Hyalochaete)	6,500	8,000	3,500	3,000	..
— sp. (Phaeoceros)	180	20	140	140	..
Corethron hystrix	10,500	7,000	9,000	5,000	1,500
Eucampia zoodiacus	128,000	81,000	150,000	82,500	..
Hemidiscus cuneiformis	..	..	20	..	..
Nitzschia closterium	1,500	1,500	1,500	..	..
— delicatissima	143,500	150,000	90,000	162,000	4,000
Rhizosolenia alata	..	..	180	> 380	..
— — f. gracillima	50	> 110	1,500	..	..
— fragilissima	1,475,000	1,300,000	975,000	750,000	4,000
Sceletonema costatum	..	2,000	4,000	5,500	..
Thalassionema nitzschioides	..	..	60	260	280
Thalassiosira bioculata	1,500	1,500	8,500	15,000	2,500
— constricta?	..	..	2,500	..	..
— gravida	8,500	8,500	3,500	+	..
— minima?	160	..	..	..	..
Thalassiothrix longissima	20	..	..	..	..
Centric diatoms not classified	..	..	..	20	..
Pennate diatoms not classified	10,000	6,500	5,500	3,000	..
Dinoflagellates:					
Ceratium longipes	40	..	..	..	..
Dinophysis borealis	40	..	..	..	..
Exuviaella baltica	12,000	8,000	7,000	2,500	..
— circularis	20	..	80	..	..
Goniaulax spinifera	20	..	..	..	..
Gymnodinium boreale	..	5,500	2,000	1,000	..
— Lohmanni	60	80	..	..	..
Gymnodiniaceae	17,500	15,500	45,000	21,000	10,000
Oxytoxum nanum	500	..	1,500	1,000	..
Peridinium breve	..	40	..	..	..
— brevipes	..	500	40	..	..
— globulus var. quarnerense	..	..	..	20	..
— minusculum	1,000	500	500	500	..
— pellucidum	40	40	..	..	..
— trochoideum	..	..	500	..	..
Phalacroma rotundatum	..	40	20	..	..
— Ruudi	500	500	1,500	> 80	..
— sp.	..	20	..	..	..
Dinoflagellates not classified	1,000	60	5,500	1,500	500
Athecate dinoflagellates	3,500	380	60	100	..
Coccolithophorids:					
Anthosphaera robusta	5,500	12,500	22,500	36,500	13,000
Calyptrosphaera hyalina	8,500	10,000	11,500	4,000	..

Table 16 (continued).
St. E10, 26. May 1948.

Depth in metres	0	10	20	30	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Coccolithus Huxleyi	120,500	162,500	167,500	157,500	26,500
— pelagicus	6,900	13,500	16,000	15,500	20,000
Syracosphaera caudata	> 4,000	4,000	> 4,000	> 13,000	> 3,000
— mediterranea	> 300	> 120	> 20	> 40	..
— Molischi	+	9,000	7,500	..	2,000
Coccolithophorids not classified	1,000	..	..	..	..
Other flagellates, etc.:					
Bodo marina	14,500	10,000	13,000	11,500	7,000
Distephanus speculum	4,750	5,000	2,000	1,000	..
Monosiga marina	500	> 1,000	..	500	..
Flagellates and monades not classified	16,500	82,500	362,500	182,500	31,000
Ciliates:					
Acanthostomella gracilis	20	..	..	..	..
— — (empty loricae)	(520)	(380)	(1,000)	(2,000)	(320)
— norvegica	80	20	..	..	..
Didinium parvulum	..	500	..	..	..
Laboea conica	1,000	1,980	60	80	..
— strobila	20	40	..	..	..
— sp.	840	540	40	60	..
Lohmanniella oviformis	3,500	9,000	13,500	3,000	1,000
Mesodinium rubrum	..	40	..	..	..
— sp.	..	..	..	..	20
Parafavella denticulata	..	..	20	20	..
— — (empty loricae)	(20)	..	(40)	(1,000)	(20)
— edentata	40	..	20	..	..
— — (empty loricae)	(180)	(100)	(80)	(60)	..
Woodania conicoides	3,000	3,000	..	> 20	1,000
Ciliates not classified	20	80	20	40	..

Table 17.

St. F1, 7. May 1948.

Depth in metres	0	10	20	30	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:					
Asterionella japonica	21,500	7,000	900	2,660	3,780
Cerataulina Bergoni	2,180	4,680	1,060	3,620	2,260
Chaetoceros affinis	..	13,000	160	..	1,740
— atlanticus	..	..	..	..	80
— borealis f. concavicornis	140	..	280	100	80
— cinctus	..	18,000	21,500[1]	..	..
— compressus	7,500	27,500	24,500	9,000	9,000
— constrictus	2,000	7,000[1]	..	700	3,300
— debilis	8,500	29,000	16,500	21,500	24,000
— decipiens	8,000	16,500	16,000	28,000	11,500
— laciniosus	300	280	300	..	320
— peruvianus	..	..	..	100	100
— radicans	8,000	9,000	1,000	10,500	6,000
— similis	..	..	500	..	60
— spp. (Hyalochaete)	11,500	7,000	..	..	1,240
Corethron hystrix	..	..	..	..	60
Coscinodiscus centralis	..	..	20	..	..
— radiatus	..	..	..	..	60
Coscinosira polychorda	520	2,200	260	2,280	1,340
Ditylum Brightwelli	220	280	340	320	400
Eucampia zoodiacus	..	..	..	40	120
Lauderia borealis	4,800	4,340	6,300	12,000	8,780
Leptocylindrus danicus	..	..	560	80	..
Melosira sulcata	..	180	..	..	220
Nitzschia closterium	2,000	3,500	1,000	500	1,500
— delicatissima	23,000	40,500	22,500	34,500	20,000
— seriata	5,500	16,000	1,500	6,000	6,820
Pleurosigma sp.	..	20	20	20	..
Rhizosolenia alata	80	250	150	160	320
— delicatula	1,000	500	160	1,500	2,000
— fragilissima	320	140	760	1,160	1,820
— hebetata f. semispina	..	120	60	20	140
— Stolterfothi	6,900	6,440	7,400	4,760	10,520
Sceletonema costatum	48,500	118,000	116,500	72,500	64,500
Thalassionema nitzschioides	6,500	1,140	1,560	660	720
Thalassiosira gravida	78,500	53,000	47,500	100,000	77,500
— Nordenskioeldi	47,000	56,500	54,000	101,000	59,000
Pennate diatoms not classified	4,000	2,000	4,500	4,000	..
Dinoflagellates:					
Ceratium furca	..	40	40	..	20
— fusus	..	20	20	20	..
— horridum	..	..	..	20	20
Dinophysis borealis	..	..	..	..	20
Exuviaella baltica	500	3,000	3,000	1,000	1,500
Glenodinium danicum	..	20	20	100	100
— lenticula	..	40	..	..	20
Gymnodinium Lohmanni	4,500	1,000	1,000	120	120
Gymnodiniaceae	1,500	6,500	9,500	4,500	3,000
Peridinium brevipes	40	80	20	..	..
— conicum	..	..	20	20	..
— crassipes	..	..	20	..	..
— globulus var. ovatum	..	..	20	..	40
— pellucidum	20	20	60	120	..
— Thorianum	20	40	..	20	..
— trochoideum	40	60	..	..	..
— sp.	..	..	..	..	20
Dinoflagellates not classified	..	20	..	..	..

[1]) Including resting spores.

Table 17 (continued).

Depth in metres	0	10	20	30	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Coccolithophorids:					
Anthosphaera robusta	..	500	..	..	..
Coccolithus Huxleyi	3,500	6,500	10,000	7,500	6,500
Syracosphaera Molischi	20	20	500	500	..
Other flagellates, etc.:					
Bodo marina	..	..	..	500	..
Dictyocha fibula	..	10	..	..	10
Distephanus speculum	10	..	..	..	10
Flagellates and monades not classified	3,000	5,500	3,500	4,000	2,000
Ciliates:					
Laboea capitata	..	..	..	20	..
— conica	220	..	..	40	..
— cornuta	..	20	..	..	..
— reticulata	20	..	..	..	..
— strobila	20	..	..	..	..
Lohmanniella oviformis	..	1,500	500	1,500	500
Mesodinium rubrum	3,500	500	20	..	..
Parafavella sp.	140	..	20	20	..
Salpingella sp.	..	..	..	..	20
Stenosemella oliva	60	40	20	..	..
Strombidium acutum	..	..	..	..	20
Woodania conicoides	3,000	20	..	..	..
Ciliates not classified	80	60	100	160	80

Table 18.

St. J15, 7. May 1948.

Depth in metres	0	10	20	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Asterionella japonica	..	..	6,000	..
Cerataulina Bergoni	1,000	5,500	6,000	80
Chaetoceros affinis	..	80	..	..
— borealis	..	60	20	..
— debilis	..	..	500	..
— decipiens	1,000	40	80	120
— sp. (Hyalochaete)	80	..	80	..
— — , resting spores	..	..	..	20
Corethron hystrix	20	..	..	..
Coscinodiscus excentricus	..	20	..	..
— lineatus	..	..	20	..
— radiatus	20	..	20	40
Leptocylindrus danicus	1,500	..	..	..
Melosira sulcata	..	940	620	900
Nitzschia closterium	..	1,500	> 40	500
— delicatissima	1,000	..	..	..
— seriata	..	500	..	200
Rhizosolenia alata	..	10	..	..
— delicatula	8,000	..	..	5,000
— fragilissima	328,000	185,500	149,000	99,500
— hebetata f. semispina	60	30	60	230
— Stolterfothi	8,500	800	680	13,500
Thalassionema nitzschioides	..	..	1,000	..
Thalassiosira bioculata	2,000	500	5,500	4,000
— decipiens	17,000	20,500	17,000	6,500
Centric diatoms not classified	..	..	3,000	..
Pennate diatoms not classified	..	..	80	20
Dinoflagellates:				
Dinophysis acuminata	120	..	..	..
Exuviaella baltica	6,500	1,500	1,500	1,000
— compressa	..	..	20	20
Glenodinium danicum	..	1,000	500	60
— lenticula	200	..	..	..
Goniaulax spinifera	60	..	..	..
Gymnodiniaceae	26,500	13,000	24,500	15,500
Peridinium brevipes	80	..	..	..
— conicum	20	..	..	..
— conicoides	..	20	..	..
— Grani	20	..	..	..
— minusculum	1,000	..	500	1,000
— pallidum	20	..	..	..
— pellucidum	920	60	..	..
— trochoideum	40	60	40	..
Phalacroma rotundatum	20	..	..	20
— Ruudi	..	..	20	..
Porella perforata	..	..	20	..
Pronoctiluca sp.	500	..	..	..
Prorocentrum micans	..	..	(20)	..
Dinoflagellates not classified	140	..	20	..
Coccolithophorids:				
Acanthoica quattrospina	2,500	..	..	..
Coccolithus Huxleyi	71,000	6,500	6,000	13,500
Other flagellates, etc.:				
Bodo marina	1,500	500	..	..
Distephanus speculum	10	10	10	..
Phaeocystis sp.	+	+	+	..

Table 18

(continued).

Depth in metres	0	10	20.	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50
Flagellates and monades not classified	5,000	2,500	6,000	3,000
Ciliates:				
Laboea conica	40	..	..	..
— strobila	40	..	..	..
Lohmanniella oviformis	> 100	> 40	2,000	..
Mesodinium rubrum	20	..	..	..
Stenosemella oliva	560	80	80	40
Woodania conicoides	1,000	..	..	..

Table 19.

St. S1, 8. May 1948.

Depth in metres	0	10	20	45
Number of ml. examined	2 & 10	2 & 10	2 & 10	2 & 10
Diatoms:				
Asterionella japonica	27,100	51,600	183,300	397,000
— kariana	..	..	..	2,400
Bacillaria paradoxa	2,800	..	..	..
Cerataulina Bergoni	100	800	300	4,000
Chaetoceros affinis	400	900	4,700	1,000
— cinctus	1,800	1,700	6,500	5,200
— compressus	1,000	..	2,600	800
— curvisetus	2,900	500	3,000	800
— danicus	200	200	1,200	400
— debilis	6,200	2,400	13,500	10,200
— decipiens	500	500	..	1,200
— densus	400	200	..	..
— laciniosus	..	800	1,200	..
— subsecundus	2,200	1,700	4,700	13,800
— Wighami?	900	..	..	..
— sp.	2,100	2,600	1,100	4,200
Coscinodiscus excentricus	..	..	..	200
Coscinosira polychorda	..	2,500	3,000	4,000
Leptocylindrus danicus	400	300	400	..
Melosira sulcata	1,000	1,500	2,600	7,400
Navicula distans	..	..	100	200
Nitzschia closterium	600	1,600	2,600	7,800
— delicatissima	2,600	1,900	4,500	18,400
— seriata	..	200	600	1,000
Pleurosigma angulatum	..	100	100	200
— fasciola	100	200	..	..
Rhizosolenia alata	100	..	..	..
— hebetata f. semispina	500	200	1,300	800
— Stolterfothi	..	..	300	..
Sceletonema costatum	29,000	70,600	254,700	1,440,000
Thalassionema nitzschioides	3,400	4,300	7,300	6,800
Thalassiosira decipiens	900	2,500	6,000	18,800
— gravida	3,300	7,200	22,400	34,600
— Nordenskioeldi	500	..	..	200
Pennate diatoms not classified	2,500	4,000	3,500	6,500
Dinoflagellates:				
Amphidinium sphenoides	..	300	300	..
— sp.	..	500	500	..
Ceratium lineatum	..	..	300	..
Dinophysis acuta	500	..	..	..
— norvegica	100	..	..	..
Exuviaella baltica	1,600	2,800	2,900	2,000

Table 19 (continued).

Depth in metres	0	10	20	45
Number of ml. examined	2 & 10	2 & 10	2 & 10	2 & 10
Glenodinium lenticula f. asymmetrica	200	100	100	..
Goniaulax spinifera	200	..	..	..
Gymnodinium Lohmanni?	500	300	1,100	1,600
Gymnodiniaceae	3,000	1,000	1,500	500
Gyrodinium spirale	..	..	..	500
Peridinium brevipes	..	..	..	400
— globulus var. ovatum	..	100	..	200
— minusculum	200	200	300	400
— pellucidum	200	..	..	..
— roseum	100	..	..	..
— trochoideum	3,500	2,500	2,900	4,600
— sp.	200	400	400	..
Phalacroma sp.	200	200	..	200
Protoceratium reticulatum	500	..	100	..
Cysts of dinoflagellates?	200	..	300	..
Other flagellates, etc.:				
Bodo marina	2,900	4,600	5,800	5,400
Carteria sp.	1,500	..	1,000	..
Dictyocha fibula	..	..	..	200
Distephanus speculum	..	100	200	600
Ebria tripartita	..	..	..	500
Euglena sp.	500	..	..	..
Monosiga marina	500	..	500	500
Trochiscia discoidea	..	100	..	..
Monades not classified	8,500	7,500	11,500	12,500
Ciliates:				
Didinium parvulum	..	..	100	..
Laboea vestita	..	100	..	..
Lohmanniella oviformis	200	1,000	600	..
Mesodinium rubrum	..	100	..	..
Metacylis mediterranea	..	..	100	..
Parafavella denticulata	..	..	100	..
Ptychocylis urnula	100	200	100	..
Tintinnopsis beroidea	..	200	..	200
Woodania conicoides	100	..	100	200
Ciliates not classified	300	100	300	400

Recorded from the net sample only:

Actinoptychus undulatus, Biddulphia mobiliensis, B. regia, B. sinensis, Chaetoceros borealis, C. similis, Coscinodiscus centralis, C. concinnus, C. marginatus, C. radiatus, Ditylum Brightwelli, Eucampia zoodiacus, Lauderia glacialis, Thalassiosira condensata, T. rotula, Ceratium furca, C. fusus, C. longipes, C. tripos, Glenodinium lenticula f. minor, Peridinium depressum, P. Grani, P. leonis, P. pallidum, P. pentagonum, P. pyriforme, P. Thorianum, Phalacroma rotundatum, Trochiscia Vanhoeffeni, Coxliella ampla.

Table 20.

St. T2, 4. May 1948 and St. T6, 5. May 1948.

Depth in metres	0	0
Number of ml. examined	2 & 10	2 & 10
Diatoms:	T 2	T 6
Asterionella japonica	18,000	100
Bellerochea malleus	4,000	..
Biddulphia aurita	6,000	..

Table 20 (continued).

Depth in metres	0	0
Number of ml. examined	2 & 10	2 & 10
Biddulphia regia	200	..
— sinensis	..	100
Campylosira cymbelliformis	16,000	600
Cerataulina Bergoni	7,000	35,000
Chaetoceros borealis	..	700
— compressus	1,000	..
— curvisetus	4,000	..
— danicus	82,000	200
— debilis	27,000	500
— decipiens	7,000	600
— densus	..	2,500
— gracilis?	..	500
— sp.	26,000	600
Coscinosira polychorda	400	..
Cymatosira belgica	200	..
Eucampia zoodiacus	3,000	..
Guinardia flaccida	..	900
Leptocylindrus danicus	42,000	..
Melosira sulcata	2,000	1,500
Navicula membranacea	2,000	..
Nitzschia closterium	127,000	16,700
— delicatissima	3,000	1,100
— seriata	14,000	1,300
Pleurosigma fasciola	..	200
— sp.	200	700
Podosira stelliger	..	200
Raphoneis amphiceros	600	300
Rhizosolenia hebetata f. semispina	1,000	18,500
— imbricata var. Shrubsolei	..	1,500
— Stolterfothi	3,000	45,000
Thalassionema nitzschioides	13,000	1,000
Thalassiosira decipiens	8,000	300
— gravida	10,000	300
Pennate diatoms not classified	65,000	6,000
Dinoflagellates:		
Dinophysis norvegica	1,000	200
Exuviaella baltica	5,000	1,500
Glenodinium lenticula f. asymmetrica	200	100
Gymnodiniaceae	4,000	..
Peridinium roseum	200	..
— sp.	200	400
Phalacroma rotundatum	..	200
Prorocentrum micans	..	100
Protoceratium reticulatum	200	..
Coccolithophorids:		
Rhabdosphaera stylifer	1,000	..
Other flagellates etc.:		
Bodo marina	2,000	1,000
Dinobryon pellucidum	1,000	..
Distephanus speculum	1,000	..
Monosiga marina	2,500	..
Phaeocystis sp.	..	+
Monades not classified	3 000	1,000
Ciliates:		
Laboea conica	1,000	400
— vestita	200	..
Lohmanniella oviformis	200	500
Tintinnopsis beroidea	2,000	100
Ptychocylis urnula	2,000	..

Table 21.

St. U4, 7. May 1948.

Depth in metres	0	10	25
Number of ml. examined	2 & 10	2 & 10	2 & 10
Diatoms:			
Biddulphia regia	100	..	..
— rhombus	200	..	..
Campylosira cymbelliformis	100	1,500	..
Cerataulina Bergoni	..	100	..
Chaetoceros sp.	..	..	500
Coscinodiscus radiatus	100	..	..
— sp.	..	..	100
Cymatosira belgica	400	..	400
Melosira sulcata	7,100	1,500	4,500
Navicula membranacea	1,900	4,600	7,500
Nitzschia closterium	500	2,500	1,500
— delicatissima	6,000	9,500	8,500
— sp. parva in Phaeocystis	r	..	..
— seriata	..	100	..
Pleurosigma angulatum	200	100	200
— sp.	500	100	600
Raphoneis amphiceros	500	..	..
Rhizosolenia alata	..	..	500
— imbricata var. Shrubsolei	100	..	..
— Stolterfothi	14,000	31,500	42,000
Thalassionema nitzschioides	200	..	200
Thalassiosira decipiens	200	300	100
— Nordenskioeldi	..	..	100
Pennate diatoms not classified	6,000	3,500	14,500
Dinoflagellates:			
Ceratium furca	100	..	..
— fusus	100	100	100
Exuviaella baltica	1,500	2,000	1,500
Glenodinium lenticula f. asymmetrica	600	1,000	100
Gymnodiniaceae	2,500	7,000	200
Peridinium brevipes	..	100	..
— conicum	..	..	200
— globulus var. ovatum	1,100	1,400	1,500
— trochoideum	100	..	500
— sp.	100	..	500
Phalacroma rotundatum	100	400	200
Porella perforata	..	..	400
Prorocentrum micans	100	100	200
Pyrocystis lunula	300	100	400
Cysts of dinoflagellates?	..	..	100
Other flagellates, etc.:			
Bodo marina	8,000	14,500	4,500
Dinobryon pellucidum	1,000	1,500	..
Distephanus speculum	..	500	..
Phaeocystis sp.	+	+	+
Trochiscia Clevei	100	..	..
— discoidea	2,700	5,500	2,500
Monades not classified	1,700	14,500	11,500
Ciliates:			
Codonellopsis sp.	600	500	500
Laboea conica	1,000	1,000	1,500
— strobila	100	500	..
— vestita	100	..	..
Lohmanniella oviformis	100	..	200
Mesodinium rubrum	100	..	..
Metacylis mediterranea	100	..	100
Woodania conicoides	400	500	300

Table 22.

St. S15, 10. May 1948.

Depth in metres	0	10	20	36
Number of ml. examined	2 & 10	2 & 10	2 & 10	2 & 10
Diatoms:				
Actinoptychus senarius	..	..	..	100
Asterionella japonica	500	..	3,500	1,500
Biddulphia aurita	..	..	..	100
— rhombus	..	..	..	200
— sinensis	400	200	100	200
Campylosira cymbelliformis	..	..	..	200
Cerataulina Bergoni	700	900	..	..
Chaetoceros affinis	500	2,600	3,100	..
— borealis	700	600	300	400
— cinctus	2,700	1,600	5,900	600
— compressus	1,600	300	400	..
— curvisetus	1,400	..	..	..
— debilis	27,800	19,800	28,500	80,800
— decipiens	2,500	2,500	5,700	4,200
— densus	..	1,700	600	900
— gracilis?	1,000	..	..	1,000
— subsecundus	2,600	1,400	700	200
— teres	..	400	..	..
— Wighami	..	..	900	..
— sp.	3,400	4,700	2,700	3,600
Coscinodiscus concinnus	200	200	500	300
— oculus iridis	..	100	200	..
— radiatus	200	..	400	200
Guinardia flaccida	..	..	100	..
Hyalodiscus subtilis	..	..	200	..
Leptocylindrus minimus	..	1,000	3,000	..
Melosira sulcata	1,600	4,700	12,500	12,100
Nitzschia closterium	200	100	500	..
— delicatissima	100	..	300	200
— seriata	..	..	..	300
Pleurosigma angulatum	..	..	100	..
Raphoneis amphiceros	..	..	100	100
— surirella	..	..	..	200
Rhizosolenia hebetata f. semispina	400	..	100	800
— imbricata var. Shrubsolei	200	100	100	..
— Stolterfothi	300	..	..	..
— styliformis	200	..	100	..
Thalassionema nitzschioides	..	..	400	600
Thalassiosira decipiens	200	100	400	300
Pennate diatoms not classified	..	1,000	1,000	8,000
Dinoflagellates:				
Amphidinium crassum	..	100	..	..
Ceratium fusus	200	200	200	300
— longipes	..	..	..	100
— macroceros	100	..	100	100
Dinophysis acuminata	300	200	200	..
— norvegica	..	..	..	100
Exuviaella baltica	200	300	200	200
Glenodinium lenticula f. asymmetrica	..	..	100	..
Gymnodinium Lohmanni	..	100	100	..
Gymnodiniaceae	500	100	..	500
Peridinium brevipes	200	100	200	300
— depressum	..	..	100	..
— globulus var. ovatum	..	..	100	..
— roseum	100	..	..	..
— trochoideum	..	100	100	100
— sp.	..	..	..	100

Table 22 (continued).

Depth in metres	0	10	20	36
Number of ml. examined	2 & 10	2 & 10	2 & 10	2 & 10
Phalacroma rotundatum	..	100	100	100
— sp.	200	..	..	200
Protoceratium reticulatum	..	..	..	100
Pyrocystis lunula	..	..	..	100
Cysts of dinoflagellates?	200	300	100	100
Coccolithophorids:				
Coccolithus Huxleyi	100	100	..	..
Other flagellates, etc.:				
Bodo marina	11,000	11,000	11,000	7,000
Distephanus speculum	..	..	200	..
Monosiga marina	3,000	..	1,000	2,000
Pediastrum Boryanum (col.)	..	100	..	..
Phaeocystis sp.	rr	rr	rr	rr
Pterosperma cristatum	..	500	100	500

Table 22 (continued).

Depth in metres	0	10	20	26
Number of ml. examined	2 & 10	2 & 10	2 & 10	2 & 10
Trochiscia Clevei	..	..	..	500
— discoidea	100	..	..	600
Monades not classified	2,000	4,500	6,500	12,000
Ciliates:				
Laboea vestita	..	100	..	..
Lohmanniella oviformis	300	300	400	400
Mesodinium rubrum	300	1,200	600	600
Woodania conicoides	..	100	100	100
Ciliates not classified	600	800	..	200

Recorded from the net sample only:

Chaetoceros constrictus, C. crinitus, Coscinodiscus marginatus, Eucampia zoodiacus, Podosira stelliger, Ceratium tripos, Dinophysis acuta, Glenodinium lenticula f. minor, Peridinium leonis, P. pallidum, P. pyriforme.

Table 23.

St. M1, 2. May 1948.

Depth in metres	0	10	20	30	58
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:					
Actinoptychus senarius	..	40	..	..	60
Asterionella japonica	2,000	500	+	> 260	..
Biddulphia rhombus	..	..	..	..	(+)
Cerataulina Bergoni	..	220	1,220	> 460	520
Chaetoceros borealis	..	..	300	40	..
— compressus	..	..	42,500[1])	2,500[1])	2,500[1])
— danicus	..	..	..	20	..
— debilis	..	..	14,000	2,500	..
— decipiens	..	..	2,000	1,000	..
— difficilis	3,720	15,500	63,500	2,000	500
— tortissimus		31,000	39,500	5,500	18,000
— spp. (Hyalochaete)	20[1])	..	3,000	2,000	..
— — (Phaeoceros)	..	..	60	..	..
Coscinodiscus concinnus	..	..	..	..	20
— curvatulus	..	..	..	..	20
— excentricus	..	..	..	..	20
— radiatus	..	20	20	..	40
— sp.	20	..	..	..	..
Eucampia zoodiacus	..	..	1,160	> 2,360	> 1,560
Guinardia flaccida	..	100	240	160	140
Leptocylindrus danicus	500[1])	..	+	+	> 100
— minimus	..	..	3,500	..	..
Licmophora sp.	..	..	..	20	..
Melosira sulcata	600	1,300	860	1,160	> 1,400
Nitzschia closterium	500	..	> 500	..	1,000
— delicatissima	..	500	1,500	..	..
— seriata	..	..	> 160	..	..
Pleurosigma sp.	20	..	> 20	40	..
Podosira stelliger	80	..	..	20	20
Rhizosolenia alata f. gracillima	..	..	50	..	..
— hebetata f. semispina	..	..	30	..	20
— imbricata var. Shrubsolei	..	..	150	190	110
— Stolterfothi	..	..	+	..	120
Sceletonema costatum	..	..	> 3,000	..	..

[1]) Including resting spores.

Table 23 (continued).
St. M1, 2. May 1948.

Depth in metres	0	10	20	30	58
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 S 50
Thalassiosira decipiens	1,500	+	+	..	..
— gravida	..	..	> 60	160	..
Centric diatoms not classified	..	..	40	500	20
Pennate diatoms not classified	500	2,000	11,500	500	20
Dinoflagellates:					
Amphidinium Klebsi?	..	..	..	40	20
Ceratium furca	..	..	120	20	..
— fusus	..	..	20	40	..
— horridum	..	..	20	20	..
— longipes	..	20	180	120	20
— macroceros	..	..	20	20	..
— tripos	..	..	..	20	..
— — f. subsalsum	..	20	80	20	..
Dinophysis acuminata	180	400	220	20	60
— acuta	..	60	..	20	20
— norvegica	180	260	160	20	120
Exuviaella baltica	..	500	1,500	..	1,500
— circularis	..	..	500	..	20
Glenodinium lenticula	100	80	20	20	40
Goniaulax Ostenfeldi	..	..	120	..	..
— triacantha	500	> 20	> 40	..	..
Gymnaster pentasterias	..	..	..	..	80
Gymnodinium boreale	> 60	> 120	> 140	60	100
Gymnodiniaceae	1,500	4,000	5,500	1,000	3,000
Peridinium brevipes	..	> 120	> 60	20	20
— depressum	..	20	..	..	..
— globulus var. ovatum	..	..	..	20	..
— pellucidum	40	20	..	..	40
— pyriforme	..	20	60	..	20
— roseum	..	..	..	40	..
— trochoideum	> 40	> 20	> 60	60	20
— spp.	..	80	..	..	..
Phalacroma rotundatum	60	80	20	20	20
Porella perforata	20	> 20	> 180	180	100
Dinoflagellates not classified	40	20	80	60	..
Cysts of dinoflagellates	..	40	20	20	..
Coccolithophorids:					
Coccolithus Huxleyi	..	..	..	..	500
Other flagellates, etc.:					
Bodo marina	500	1,000	4,500	500	..
Pterosperma cristatum	..	> 20	500	..	1,000
Trochiscia sp.	..	20	..	20	..
Flagellates and monades not classified	5,000	11,500	8,000	7,000	1,000
Ciliates:					
Laboea conica	80	80	40	..	..
— strobila	100	80	> 20	..	..
— spp.	..	80	..	20	..
Lohmanniella oviformis	6,000	3,000	6,500	6,000	2,000
Mesodinium rubrum	100	500	2,500	..	..
Stenosemella oliva	..	20	..	..	..
— ventricosa	..	20	..	..	..
Tintinnopsis parvula	140	120	20	40	60
— sp.	20	280	+	..	20
Woodania conicoides	> 40	+	1,000	..	..
Ciliates not classified	..	100	80	..	..

Table 24.

St. N3, 3. May 1948.

Depth in metres	0	10	20	30	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:					
Cerataulina Bergoni	..	..	80	..	..
Chaetoceros borealis	240	80	..	..	..
— compressus	200	..	(+)	..	..
— debilis	..	..	160	..	..
— decipiens	160	..	..	..	..
— sp. (Hyalochaete)	100	..	..	..	..
Coscinodiscus radiatus	..	..	..	..	20
Leptocylindrus danicus	2,500	1,000	28,000	13,500	1,000
Licmophora sp.	500	..	..	..	..
Melosira sulcata	..	..	140	..	100
Nitzschia closterium	..	..	20	..	..
— delicatissima	4,500	..	..	500	..
— seriata	120	..	160	..	..
Rhizosolenia alata	..	..	..	40	..
— fragilissima	..	80	..	..	..
— Stolterfothi	..	..	..	720	..
Roperia tessellata	..	..	..	..	20
Thalassionema nitzschioides	1,500	1,500	40	20	..
Pennate diatoms not classified	20	..	20	20	..
Dinoflagellates:					
Ceratium fusus	..	40	..	..	..
— furca	..	20	..	..	..
— longipes	20	440	..	..	..
— macroceros	..	20	..	20	..
— tripos	..	40	..	..	..
— — f. subsalsum	20	20	..	..	..
Dinophysis acuta	20	..	..	..	..
— borealis	760	600	20	20	..
— islandica	..	40	..	..	..
— Lachmanni	60	80	..	..	..
— norvegica	..	160	..	..	(20)
Exuviaella baltica	..	4,500	1,500	..	..
Glenodinium lenticula	..	..	..	20	..
Goniaulax Ostenfeldi	20	..	..	..	..
— triacantha	..	> 20	..	..	..
— sp.	20	..	..	..	500
Gymnaster pentasterias	..	20	..	20	..
Gymnodinium boreale	..	100	500	1,000	..
— Lohmanni	40	..	..	..	..
Gymnodiniaceae	19,000	57,500	16,000	7,500	20,000
Peridinium brevipes	60	..	..	..	..
— conicum	..	20	..	..	..
— depressum	..	..	20	20	..
— globulus var. quarnerense	20	..	..	..	..
— minusculum	500	..	..	..	..
— pellucidum	60	..	..	20	20
— Steini	60	..	40	..	..
— trochoideum	2,000	500	..	..	..
Phalacroma rotundatum	20	..	..	..	20
Porella perforata	20	> 60	..	..	..
Protoceratium reticulatum	20	20	..	..	..
— — , cysts	40	..	..	..	..
Pyrocystis sp.	20	..	..	..	..
Dinoflagellates not classified	1,000	6,000	..	500	500
Coccolithophorids:					
Coccolithus Huxleyi	..	500	..	..	..

Table 24 (continued).
St. N3, 3. May 1948.

Depth in metres	0	10	20	30	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Other flagellates, etc.:					
Bodo marina	13,000	4,000	1,000	1,000	1,500
Carteria sp.	500	..	..	..	..
Monosiga marina	> 2,500	..	1,000	500	500
Flagellates and monades not classified	> 67,000	> 95,000	> 47,000	> 12,000	> 66,000
Ciliates:					
Didinium parvulum	..	500	..	+	+
Laboea conica	40	80	..	..	..
— emergens	..	..	40	..	..
— strobila	..	60	..	..	..
— sp.	20	..	..	..	..
Lohmanniella oviformis	+	2,500	1,000	500	500
Mesodinium rubrum	180	60	..	20	..
Tintinnopsis beroidea	60	..	..	..	..
— parvula	20	..	..	..	..
Woodania conicoides	> 160	40	20	..	20
Ciliates not classified	..	20	20	..	..

Table 25.
St. Q14, 5. May 1948.

Depth in metres	0	10	20	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Melosira sulcata	..	..	..	140
Rhizosolenia hebetata f. semispina	..	..	10	10
Pennate diatoms not classified	40	..	..	20
Dinoflagellates:				
Ceratium horridum	40	..	20	..
— tripos	..	40	..	20
— — f. subsalsum	40	..	..	..
Exuviaella baltica	1,500	3,000	1,500	..
— sp.	..	20	..	..
Exuviaellaceae	..	..	..	500
Gymnaster pentasterias	..	60	..	..
Gymnodinium boreale	20	..	..	500
Gymnodiniaceae	2,000	2,000	1,500	4,000
Dinoflagellates not classified	..	> 20	500	..
Peridinium brevipes	..	..	..	20
— depressum	20	..	..	140
— globulus var. ovatum	..	..	..	160
Coccolithophorids:				
Anthosphaera robusta	..	..	..	2,000
Coccolithus Huxleyi	1,500	500	..	..
Other flagellates, etc.:				
Euglenaceae	..	..	40	..
Halosphaera viridis	..	..	20	..
Ciliates:				
Didinium parvulum	..	> 40	..	40
Laboea conica	60	20	20	..

Table 25
(continued).

Depth in metres	0	10	20	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50
Lohmanniella oviformis	..	..	1,000	..
Mesodinium rubrum	2,260	2,480	1,840	80
Woodania conicoides	100	120	..	..
Ciliates not classified	40	40	..	..

Table 26.
St. S7, 9. May 1948.

Depth in metres	0	10	20	27
Number of ml. examined	2 & 10	2 & 10	2 & 10	2 & 10
Diatoms:				
Actinoptychus senarius	..	..	..	100
Biddulphia aurita	..	..	..	100
Chaetoceros curvisetus	200	..	..	..
— subsecundus	..	..	100	..
Coscinodiscus concinnus	..	..	..	300
Diploneis sp.	..	..	200	..
Guinardia flaccida	..	..	..	100
Leptocylindrus danicus	..	..	..	100
— minimus	1,000	..	..	400
Melosira sulcata	..	..	300	..
Navicula distans	..	..	100	..
Nitzschia closterium	200	500	1,400	900
— delicatissima	..	100	100	300
— seriata	..	100	..	..
— sp. parva in Phaeocystis	200	..	..	..

Table 26
(continued).

Depth in metres	0	10	20	27
Number of ml. examined	2 & 10	2 & 10	2 & 10	2 & 10
Pleurosigma angulatum	100	..	..	400
Rhizosolenia alata	300	100	..	300
imbricata var. Shrubsolei	24,000	23,800	23,700	30,400
— styliformis	..	100	..	..
Pennate diatoms not classified	..	500	1,000	700
Dinoflagellates:				
Amphidinium sp.	..	500	..	..
Ceratium furca	..	600	..	..
— fusus	..	..	100	..
— lineatum	200	100	..	..
— longipes	..	100	100	100
— macroceros	100	..	..	..
— tripos	..	..	..	100
Dinophysis acuminata	100	100	..	..
— acuta	..	100	..	..
— norvegica	100	500	400	800
Exuviaella baltica	2,200	2,400	1,900	2,800
Glenodinium lenticula f. asymmetrica	..	..	100	..
Goniaulax sp.	..	..	100	..
Gymnodinium Lohmanni	..	..	100	..
Gymnodiniaceae	500	..	..	1,000
Peridinium brevipes	200	..	..	400
— globulus var. ovatum	..	100	200	100
— trochoideum	200	..	..	..
— sp.	..	100	..	..
Phalacroma rotundatum	200	..	..	..
— sp.	..	100	..	..
Porella perforata	500	200	300	800
Protoceratium reticulatum	..	..	200	200
Other flagellates, etc.:				
Bodo marina	500	500	400	500
Carteria sp.	..	500	500	..
Monosiga marina	7,000	11,500	11,000	5,000
Phaeocystis sp.	..	..	..	rr
Pterosperma cristatum	..	..	100	300
Trochiscia discoidea	..	..	500	..
Monades not classified	4,500	12,500	18,000	13,500
Ciliates:				
Laboea conica	100	100	..	100
— strobila	400	300	..	..
Lohmanniella oviformis	600	400	500	300
Woodania conicoides	100	100	100	500
Ciliates not classified	200	..	..	300

Recorded from the net sample only:

Cerataulina Bergoni, Chaetoceros borealis, Coscinodiscus radiatus, Rhizosolenia hebetata f. semispina, Glenodinium lenticula f. minor, Goniaulax spinifera, Noctiluca miliaris, Peridinium depressum, P. pallidum, Pyrocystis lunula, Trochiscia Clevei, T. Vanhoeffeni, Ptychocylis urnula.

Table 27.
St. J 13, 7. May 1948.

Depth in metres	0	10	20	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Chaetoceros borealis	..	40	..	..
— debilis	..	40	..	160
— decipiens	..	100	100	..
— sp. (Hyalochaete)	..	40	..	..
Corethron hystrix	20	..	..	..
Coscinodiscus Kützingi var. glacialis	60	20	20	..
— radiatus	..	..	..	20
— sp.	..	..	20	..
Leptocylindrus danicus	1,500	..	..	..
Melosira sulcata	100	..	240	220
Nitzschia closterium	> 20	> 20	..	> 20
— seriata	140	280	60	160
Rhizosolenia alata	..	60	60	..
— hebetata f. semispina	..	240	320	20
— Stolterfothi	..	..	60	..
— styliformis	30	170	240	10
Thalassiosira bioculata	5,000	7,500	6,000	1,500
— decipiens	..	..	..	40
Pennate diatoms not classified	20	..	20	20
Dinoflagellates:				
Amphidinium sp.	3,500	..	..	..
Exuviaella baltica	63,500	110,500	2,000	1,500
Glenodinium danicum	57,500	45,000	1,500	340
Goniaulax spinifera	60	..	..	..
Goniaulax sp.	60	..	..	..
Gymnodinium Lohmanni	..	20	..	..
Gymnodiniaceae	105,000	404,000	77,500	24,500
Peridinium minusculum	..	1,500	..	500
— sp.	20	..	..	..
Phalacroma rotundatum	..	20	..	..
Pronoctiluca pelagica	..	1,500	2,000	1,000
— sp.	..	> 500	> 1,000	..
Coccolithophorids:				
Acanthoica quattrospina	12,500	27,000	2,500	2,500
Coccolithus Huxleyi	30,500	38,000	20,500	13,500
Other flagellates, etc.:				
Bodo marina	9,000	9,500	16,000	2,000
Distephanus speculum	40	..	40	30
Phaeocystis sp.	+	+	+	+
Flagellates and monades not classified	146,500	139,000	34,500	10,000
Ciliates:				
Laboea conica	12,000	160	..	120
— strobila	660	60	..	..
Lohmanniella oviformis	40	..	20	120
Mesodinium rubrum	1,500	2,500	..	..
Woodania conicoides	8,000	17,000	140	40
Ciliates not classified	..	..	60	60

Table 28.

St. F9, 8. May 1948.

Depth in metres	0	10	20	30	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:					
Achnanthes sp.?	100	..	..	..	..
Asterionella japonica	> 4,880	12,000	13,000	15,000	5,000
Cerataulina Bergoni	77,000	97,500	132,500	138,500	46,500
Chaetoceros affinis var. Willei	4,000[1]	2,500	..	..	..
— atlanticus	..	..	..	240	..
— borealis	100	20	100	..	320
— — f. concavicornis	..	..	20	..	..
— compressus	+	..	6,000	7,000	680
— constrictus	..	..	> 320[1]	..	..
— convolutus	..	120	40	..	60
— curvisetus	..	..	..	3,500	..
— debilis	69,500	55,000	75,000	55,000	36,000
— decipiens	> 260	> 160	> 800	..	440
— diadema	+	..	11,000	18,500	9,500
— laciniosus	..	3,000	..	2,000	..
— radicans	11,500[1]	29,000[1]	95,000[1]	152,500[1]	43,000[1]
— spp. (Hyalochaete)	10,000	13,500	3,500	12,000	3,500
— — (Phaeoceros)	..	..	60	100	160
— — , resting spores	..	20	..	..	3,000
Corethron hystrix	20	40	..	..	..
Coscinodiscus radiatus	..	..	..	20	20
Coscinosira Oestrupi	..	..	..	200	..
— polychorda	..	..	180	120	300
Eucampia zoodiacus	..	9,500	3,500	3,000	..
Lauderia borealis	12,900	14,800	20,500	14,320	8,800
Leptocylindrus danicus	5,500	+	7,000	14,000	25,000
— minimus	+	..	..	..	..
Nitzschia closterium	3,500	3,500	2,500	8,500	..
— delicatissima	90,500	28,000	40,000	75,000	100,000
— seriata	45,000	52,000	73,000	63,500	46,500
Rhizosolenia alata + f. gracillima	200	130	1,000	110	360
— delicatula	1,000	1,500	3,500	4,500	2,000
— fragilissima	16,500	10,500	43,500	15,500	5,000
— hebetata f. semispina	780	1,100	230	40	500
— imbricata var. Shrubsolei	..	..	..	50	10
— Stolterfothi	8,960	29,000	26,000	25,000	9,900
— styliformis var. longispina	520	750	410	2,000	340
— — f. bidens	..	..	..	10	..
Roperia tessellata	..	20	60	..	20
Sceletonema costatum	..	..	..	3,500	..
Thalassionema nitzschioides	> 80	..	..	..	> 320
Thalassiosira bioculata	..	..	..	500	..
— decipiens	> 60	..	..	..	..
— gravida	4,900	5,400	7,200	14,900	16,000
— Nordenskioeldi	..	1,000	..	..	..
— sp.	> 40	..	..	5,000	..
Pennate diatoms not classified	..	..	..	1,500	..
Dinoflagellates:					
Ceratium azoricum	..	..	..	40	..
— furca	40	80	..	..	20
— fusus	20	60	60	80	20
— horridum	..	..	..	40	20
— longipes	40	..	..	..	..
— tripos	40	20	..	20	20
Exuviaella apora?	..	..	..	20	..
— baltica	5,000	2,000	500	..	..
— circularis	20	..	..	20	..

[1]) Including resting spores.

Table 28 (continued).
St. F9, 8. May 1948.

Depth in metres	0	10	20	30	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Glenodinium lenticula	20	..	40	40	40
Goniaulax spinifera	(20)	..	..	..	..
Gymnodinium boreale	..	500	..	500	20
— Lohmanni	2,500	120	180	200	100
Gymnodiniaceae	6,000	16,000	8,500	8,000	1,500
Peridinium breve	..	20	..	..	..
— brevipes	20	40	..	..	20
— depressum	..	..	..	..	40
— globulus var. ovatum	..	80	20	20	40
— — var. quarnerense	..	..	40	..	80
— subinerme	..	20	..	..	..
— trochoideum	..	..	..	60	..
— sp.	..	40	..	..	..
Phalacroma rotundatum	..	..	20	..	..
Dinoflagellates not classified	500	20	40	1,500	1,000
Athecate dinoflagellates	60	220	>1,400	900	600
Cysts of dinoflagellates	..	..	..	..	20
Coccolithophorids:					
Anthosphaera robusta	..	..	..	500	..
Coccolithus Huxleyi	5,000	13,500	1,500	5,000	..
— pelagicus	..	60	80	>180	..
Syracosphaera mediterranea	..	..	20	..	..
Other flagellates, etc.:					
Bodo marina	..	..	500	..	500
Halosphaera viridis	20	..	40	20	..
Monosiga marina	..	..	500	500	..
Phaeocystis sp.	+	+	..	+	+
Sphæropsis lævigata	..	..	..	20	..
Flagellates and monades not classified	6,500	3,000	500	5,500	500
Ciliates:					
Acanthostomella gracilis (empty loricae)	..	..	(20)	..	..
Didinium parvulum	..	..	500	..	..
Laboea conica	1,160	100	..	..	..
— strobila	..	100	40	..	..
— sp.	20	40	20	..	..
Lohmanniella oviformis	1,500	3,000	3,500	1,000	2,000
Mesodinium rubrum	660	1,380	40	40	20
Parafavella denticulata (empty loricae)	(20)	(20)	(20)	..	..
Salpingella acuminata	..	..	20	..	..
Woodania conicoides	1,500	1,500	..	..	..
Ciliates not classified	..	40	40	60	>20

Table 29.

St. H8, 4. May 1948.

Depth in metres	0	10	20	30	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:					
Cerataulina Bergoni	1,520	2,000	2,640	460	160
Chaetoceros atlanticus	80	200	..	..	180
— borealis	60	140	80	..	180
— cinctus	..	20	..	..	..
— compressus	..	180	..	260	..
— curvisetus	80	..	..	..	..
— debilis	104,500	186,000	185,000	16,000	660
— decipiens	320	200	180	200	140
— furcellatus	34,500	34,000	22,500	4,000	4,500
— laciniosus	2,000	5,500	300	260	..
— peruvianus	..	40	..	..	..
— teres	..	220	..	..	..
— tortissimus	80,500	35,000	25,000	1,140	..
Coscinodiscus radiatus	..	..	..	40	20
Eucampia zoodiacus	800	360	1,060	100	..
Lauderia borealis	120	360	..	..	..
Leptocylindrus danicus	107,500	58,500	47,000	5,740	340
Nitzschia closterium	2,000	500	500	2,000	..
— delicatissima	53,500	44,000	21,000	11,000	300
— seriata	1,980	10,000	1,700	1,780	40
Rhizosolenia alata	230	130	170	100	10
— delicatula	..	1,000	..	..	..
— fragilissima	420	45,500	35,000	1,520	100
— hebetata f. semispina	40	..	..	..	..
— imbricata var. Shrubsolei	..	90	40	..	..
— Stolterfothi	..	880	180	..	..
Sceletonema costatum	7,000	2,500	6,000	5,500	..
Thalassionema nitzschioides	..	80	..	..	..
Thalassiosira gravida	2,200	6,500	11,500	600	160
— Nordenskioeldi	48,000	20,000	6,000	380	160
Pennate diatoms not classified	..	..	..	..	20
Dinoflagellates:					
Ceratium furca	20	40	..	..	..
— fusus	60	160	20	20	..
— horridum	..	20	160	20	..
— longipes	20	40	..	..	..
— macroceros	20	..	..	..	..
— tripos	20	..	140	..	..
Dinophysis acuta	..	20	..	..	..
Exuviaella baltica	3,000	500	1,000	..	..
Glenodinium lenticula	..	40	20	..	..
Goniaulax Ostenfeldi	40	..	..	..	..
Gymnodinium boreale	500	500	20	..	..
— Lohmanni	20	..	..	..	..
Gymnodiniaceae	2,000	3,500	5,500	4,000	1,500
Peridinium conicoides	20	120	40	20	..
— conicum	40	..	..	..	..
— depressum	40	120	..	..	..
— globulus var. ovatum	..	20	..	40	..
— minusculum	..	1,500	..	..	..
— trochoideum	20	..	..	..	..
Phalacroma rotundatum	..	..	20	..	..
Pronoctiluca pelagica	500	..	..	..	..
Dinoflagellates not classified	..	..	40	20	40
Coccolithophorids:					
Anthosphaera robusta	..	..	..	1,000	..
Coccolithus Huxleyi	3,500	8,500	9,500	13,000	..

Table 29 (continued).
St. H8, 4. May 1948.

Depth in metres	0	10	20	30	50
Number of ml. examined	2 & 50	2 & 50	2 & 50	2 & 50	2 & 50
Other flagellates, etc.:					
Bodo marina	500	..	..	..	..
Distephanus speculum	..	10	..	..	..
Halosphaera viridis	20	..	..	..	..
Flagellates not classified	..	..	..	1,000	..
Flagellates and monades not classified	..	..	..	2,000	..
Ciliates:					
Didinium parvulum	..	..	..	20	..
Laboea conica	40	140	80	..	..
— strobila	40	..	40	60	..
Lohmanniella oviformis	..	..	>60	1,000	..
Mesodinium rubrum	..	20	20	120	40
Woodania conicoides	500	..	..	..	..

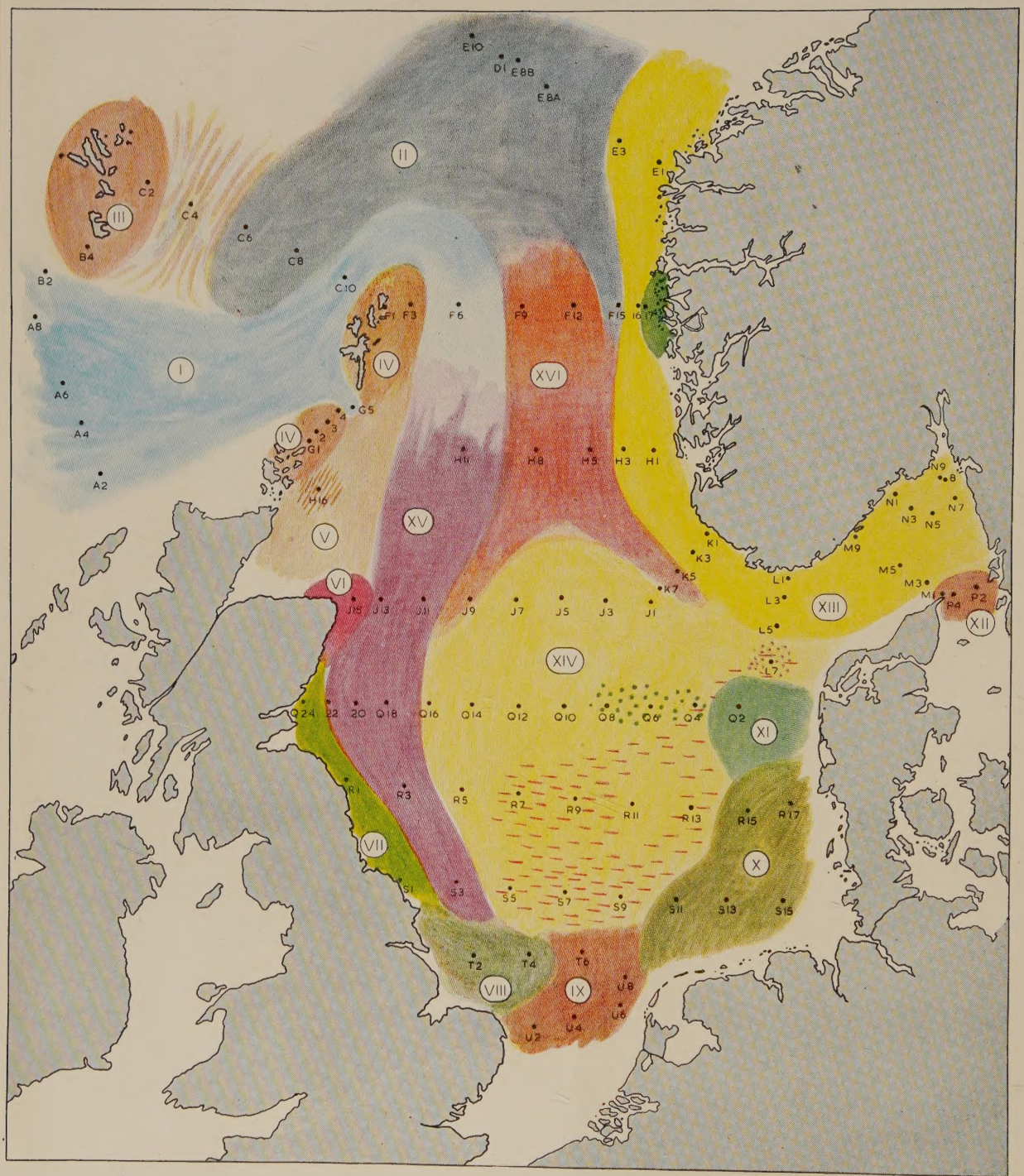

Plate A. Vegetation areas (I—XVI) in the North Sea and adjacent waters in May 1948.

Plate B. Vegetation areas (G I, G II ···) in the North Sea and adjacent waters in May—June 1912, based upon tables in Gran (1915). Corresponding areas in Plates A and B have the same numbers.